

*A webcomic of romance, sarcasm,
math, and language*

xkcd

RANDALL MUNROE

2021

xkcd

2021

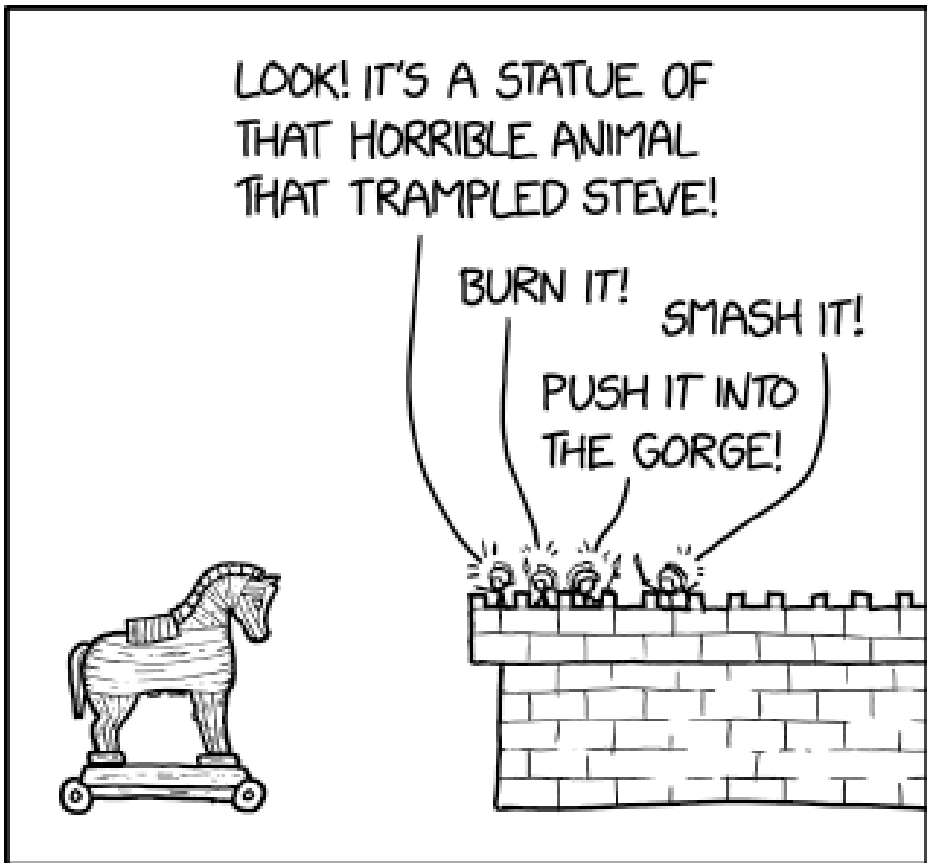
a collection of 157 webcomics

from #2406 to #2562

by Randall Munroe

#2406: Viral Vector Immunity

January 01, 2021



HOW VACCINE FAILURE DUE TO VIRAL VECTOR IMMUNITY WORKS

We've secretly replaced this customer's instant coffee with our patented substitute. Let's see what she ... uh oh, I think she spotted us through the window. Now she's getting something from the closet ... oh jeez, she has a sword! Run!!

Explanation

This comic is another in a series of comics related to the COVID-19 pandemic. This comic is the third of five releases, following 2402: Into My Veins and 2404: First Thing, which reference the new COVID-19 vaccine. It was released on New Years day, without being a New Year comic. This had not happened since 2010.

The comic attempts to explain a virus vector vaccine and one way it can fail, using the story of the Trojan Horse as an analogy. Note that neither the Pfizer/BioNTech nor Moderna vaccines are virus vector vaccines, using lipid nanoparticles for delivery rather than viruses.

A vaccine is a way to familiarize a host's immune system with a pathogen without actually causing the host to fall ill. There are many types of vaccines that have been developed, all of which are ways to present a significant segment of a pathogen's molecular structure to the host body, so that the immune system recognizes the pathogen and mounts an immune response faster when a real infection happens.

A viral vector is a tool used by molecular biologists to deliver genetic materials into cells.

A viral vector vaccine, also known as a live vector vaccine, uses a modified virus, different from the pathogen being immunized against, as a carrier to deliver a molecular payload into the host body. This modified virus is called

the vector because it is the method of delivery of a piece of the pathogen's genetic code. If the recipient has a strong immune response to the vector itself (i.e., the proteins making up the surface of the vector virus), the immunization may be less effective because the vector virus, and hence its payload of viral genetic material, will be destroyed before they can enter the host's cells. It is to some degree a dice roll, with regard to whether some recipients will already be immune to a vector.

For example, a modified (to be harmless) cold virus can be used to deliver genetic material (RNA or DNA) of another virus into the patient's cells. The cells are induced to manufacture protein found in the pathogenic protein, which the patient's immune system detects and reacts to. That way the immune system recognizes the pathogenic virus without actually being infected with it, which decreases the time needed to react to a real infection. Any patients whose immune systems recognize the modified cold virus (the vector), and destroy it rapidly, won't get the full intended benefit of creating a strong immune response to the second virus (the payload inside).

The comic represents this idea with the Trojan horse being the vector, carrying a payload of Greek soldiers into the cell, as represented by the City of Troy. In the original Trojan Horse story, Greek soldiers hid inside a statue of a horse which the Trojans were told was a gift to Athena; the Trojans brought it within their walls (which the Greek army had failed to penetrate in an extended siege), allowing the soldiers in the horse to undermine the

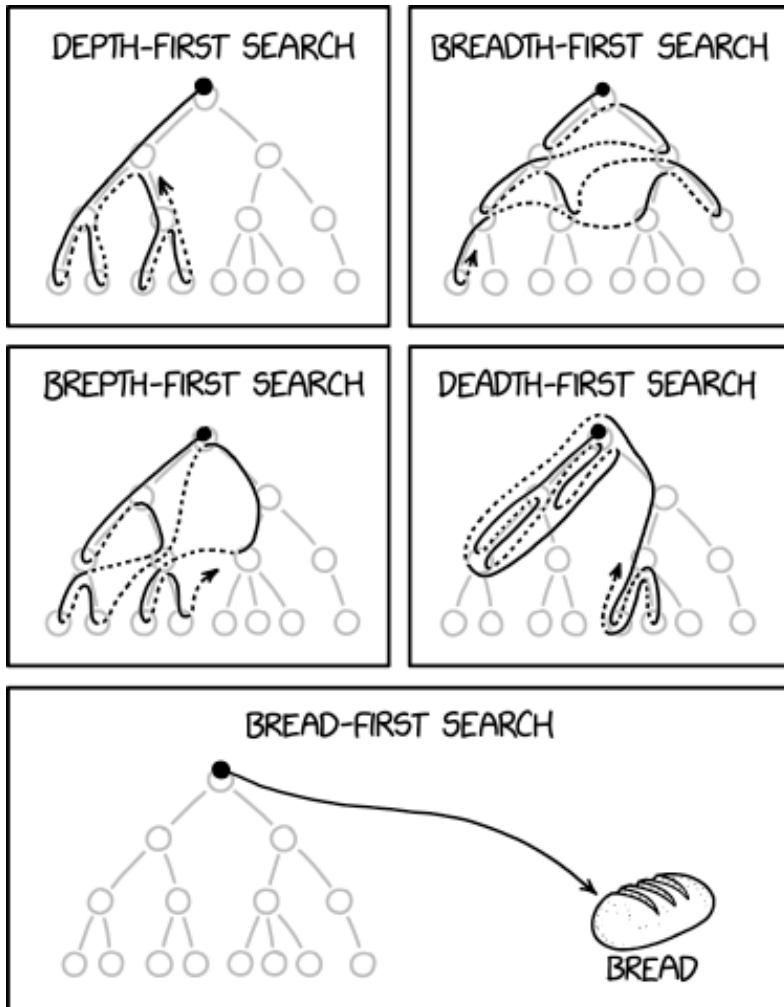
city's defenses and let in the rest of their army to take the city. Note: In a viral vector vaccine, the payload inside the vector works to the benefit of the person receiving the vaccine - opposite to the soldiers inside the Trojan horse, who had only malice in mind for the city receiving the "gift" horse.

In the comic the warriors, rather than finding the wooden horse a benign object, recognize the shape of the delivery vehicle (the Trojan horse) as being similar to an animal that trampled one of their own earlier and therefore refuse it entry. An amusing point here is that they are not as such surprised at the arrival of a wooden vehicle at their doorstep, rather that its shape resembling an animal they have found threatening before, which is similar to how simple in its judgements the immune system can be. (In addition, although the warriors suggest pushing the wooden horse into a gorge, there are no gorges very close to Troy, which is situated close to the sea on the Plain of Troy.)

The title text is a further riff on this theme, playing on an advertising campaign for freeze dried coffee. In the advertisements a narrator would claim to have secretly replaced fresh brewed coffee with that made from freeze dried to see if subjects could tell the difference, the contents of the coffee cup being the payload and the narrator the virus vector. The test subject's use of a sword relates the situation back to the Trojan scenario of the panel.

#2407: Depth and Breadth

January 04, 2021



A death-first search is when you lose your keys and travel to the depths of hell to find them, and then if they're not there you start checking your coat pockets.

Explanation

Tree structures are one of the most common data structures used in computer science. The common ways of enumerating items arranged in a tree is either depth-first, or breadth-first, which are depicted accurately in the comic. Randall humorously combines the words, to produce "brepth-first", "death-first", "bread-first", and "death-first" search algorithms.

Depth-first search explores down a full branch of the tree before working back to a higher level. This type of tree structure was already discussed as inefficient for human needs in 761: DFS. The "opposite" of this is breadth-first search, which explores each level of the tree at a time.

In the "brepth-first" algorithm, a depth-first and a breadth-first search are hybridized where the left-most node is visited more frequently than the right node, but the right node is still visited. This might be good for exploring data that is loosely but not strictly weighted to the left, or where data in deeper nodes needs some time to be loaded before it can be used. As implied by 761: DFS, this might be the best algorithm for a human to employ, where one can explore several topics briefly before deciding which one to explore more deeply, rather than blindly following the first rabbit hole to an absurd conclusion. Informed search algorithms like A* search, Beam search, and other Best-first search algorithms show this type of behavior by expanding the most promising node in the current set (under some appropriate metrics).

The nature of the "death-first" algorithm is unclear and inefficient, since it searches the same nodes multiple times before moving to an entirely different region of the tree. It might be useful in a context where examining nodes has some probability of returning a noisy or incorrect result, such as searching for small objects that may be overlooked.

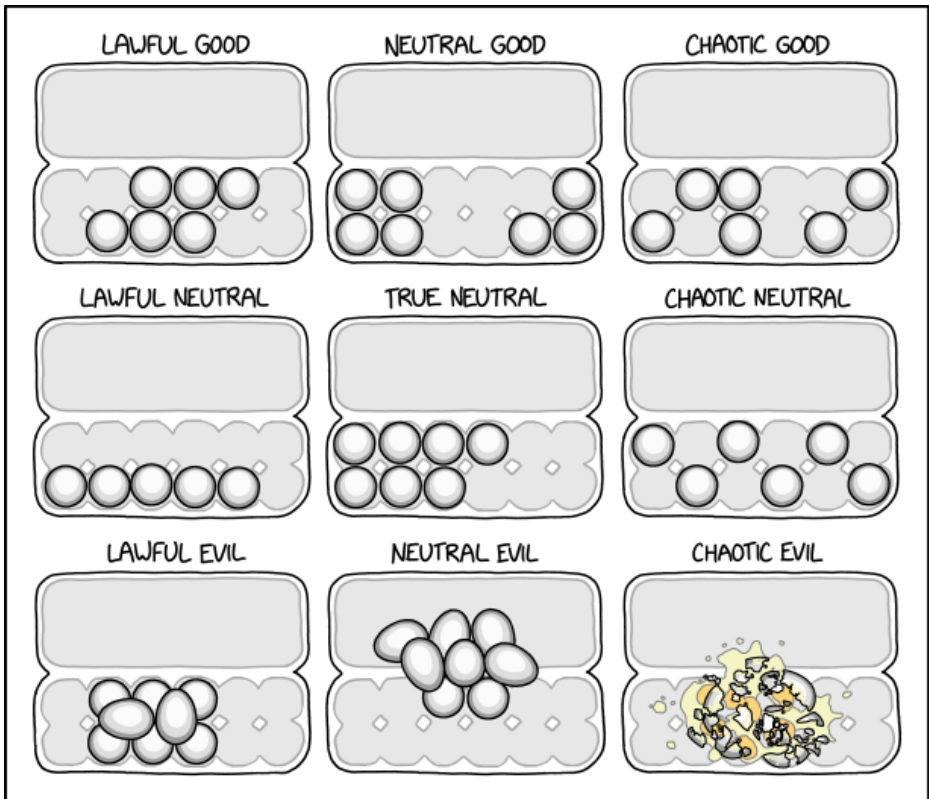
It may also be how people with OCD search, but this would be very stereotypical.

The bread-first search is taken literally. Bread is searched for first. Since the computer user (probably Beret Guy) now has already met their want to find bread, the computer has no reason to explore the tree at all.[citation needed]

The title text introduces a "death-first" search, in which the user explores what it is like to be dead, before considering anything else. Specifically, the title text refers to hell, which calls to mind the adventures of Dante Alighieri in his *Inferno*, and is a less likely place for keys to be left than one's coat pockets.[citation needed] In 2021 (the year this comic was published) there are commemorations for the 700th anniversary of Dante's Death. These are expected to take place among the living only, and not in Hell.[citation needed] A much more pleasant death-first algorithm might be to skip hell and purgatory and search heaven first, perhaps multiple times (which in itself would be a use of the death-first approach).

#2408: Egg Strategies

January 06, 2021



Neutral Evil is for people who like keeping the weight nicely centered in the carton, but also hate everyone else who wants that.

Explanation

This comic shows nine egg cartons, each of which contains between five and eight eggs. The cartons are presented in the format of a Dungeons & Dragons alignment chart. Originally created as a way of categorizing game characters' motivations, the chart has three possibilities on each axis: lawful/neutral/chaotic on the X (obedience) axis and good/neutral/evil on the Y (intentions) axis. Used outside its original purpose, the chart has become a meme for categorizing things it has no real applicability to. This comic is one such meme. The rationale for deciding how good or evil an arrangement is based on how the eggs are balanced in the carton.

Eggs in America are traditionally sold by the dozen, with egg cartons consisting of 12 cups to hold them in place. A consumer is unlikely to consume all 12 eggs at once[citation needed] (unless feeding a great many people, or perhaps making a traditional pound cake), which means that the carton will be gradually emptied. Different people have different tendencies as to the order in which they remove eggs. This comic depicts various possible storage schemes for the unused eggs and assigns them D&D alignments.

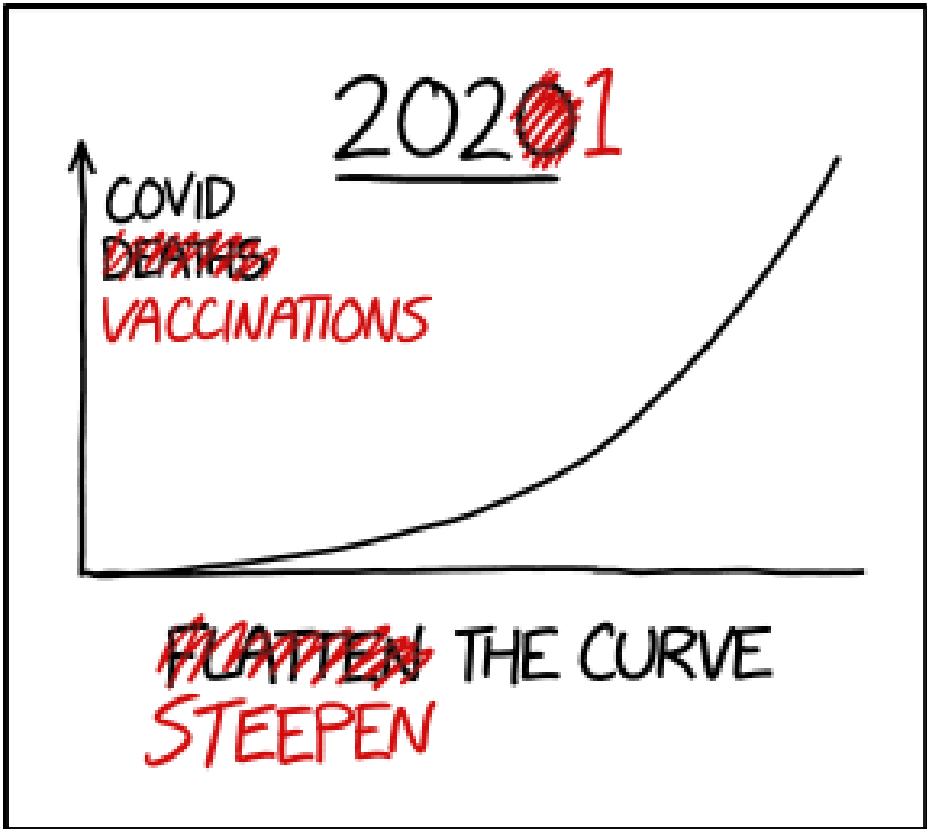
By the standards of this comic, "good" attributes appear to include targeting having symmetry, with a center of gravity near the center of the carton. Presumably, this is considered to make the carton easier to handle and less

likely to cause problems for anyone else who uses the carton. The "evil" alignments appear to go out of their way to make the carton eggs harder to use, with the ultimate example of simply smashing all the eggs.

An alignment chart was also featured in 2251: Alignment Chart Alignment Chart, which was published exactly one year earlier.

#2409: Steepen the Curve

January 08, 2021



1. Flatten the curve. 2. Steepen the curve. 3. Hang out.

Explanation

This comic is another in a series of comics related to the COVID-19 pandemic.

In early 2020, the COVID-19 pandemic rapidly became the main public concern. The virus spread at an exponential rate before initial lockdowns started to reduce the trajectory for a time. The graphic drawn in black depicts exponential growth in the measure of deaths — though it is not clear (without proper units or values on either axis) if this is because it is a cumulative count of deaths or the rate of deaths per day. Such graphs were common in the spring of 2020, enough that Randall has previously parodied them in 2294: Coronavirus Charts. These graphs often showed future projections that compared continued exponential growth vs. curves that did not grow as fast, or even flattened out. Governments around the world realized that if the trend was to continue healthcare services would become overwhelmed, thus all kinds of political, civic and personal efforts were put towards doing things that would cause the 'curve' to flatten and not rise as rapidly as it would do unchecked. "Flatten the curve" thus became the rallying cry for all measures taken to reduce the spread of the virus.

In 2021, the pandemic is ongoing (with second or even third 'waves' of resurgence affecting some populations that had temporarily flattened the curve) but now we have a handful of vaccines available. In 2278: Scientific

Briefing, White Hat remarked that many scientific briefings use similar or identical charts, but in this briefing, a chart from the beginning of the pandemic is reprinted verbatim and then crudely updated with red ink. The red overlay intends to update the 'original' graphic to portray the number of vaccines provided (again, it could easily be either cumulative or rate-wise). With the change to what is represented, the line remains the same but the hoped-for outcome is changed accordingly. Making the curve steeper represents getting more people vaccinated faster.

In both cases, there would be an upper limit on the cumulative value, but the ceiling must be well beyond the upper limits (x and y axes) of this graph. If this is a rate-graph, it would show a peak and subsequent decline at the same point in time where a cumulative graph would show an inflection in its gradient, but neither are visible here.

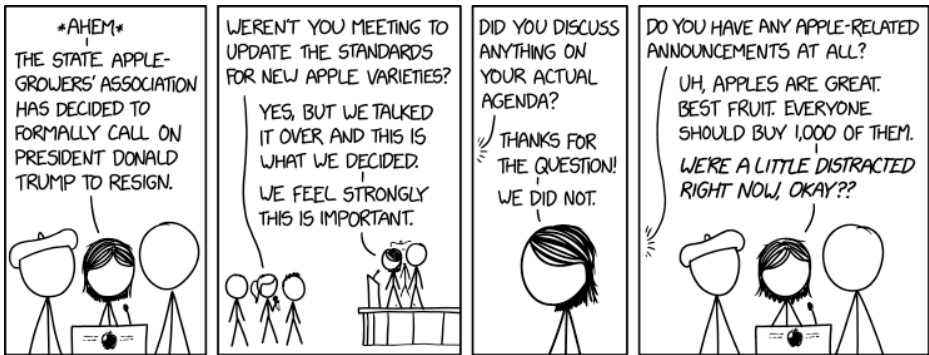
Additionally, the analogy between the number of deaths and the number of vaccinated people could be considered as questionable, as the number of deaths in the initial stages of a pandemic is expected to follow an exponential law, whereas the same cannot be said for the number of vaccinated people.

The title text gives a summary of the overall goal. Flatten the curve (of infections/deaths), Steepen the curve (of vaccinations/immunizations), Hang out (if possible). We've done the first, we're starting the second... and the third is where we can (hopefully) all hang out together

again, in person, without masks or social distancing. But we have to finish the first two steps successfully to get to the third one.

#2410: Apple Growers

January 11, 2021



Hopefully in a couple of weeks we'll be able to resume our apple-focused updates, because we have **SO MUCH** to say about Cosmic Crisp.

Explanation

On January 6, 2021, a group of supporters of President Donald Trump stormed the United States Capitol while Congress was in session to certify the results of the 2020 election, in which President Trump lost a bid for re-election. The attack resulted in an evacuation of Congress, a disruption of the operations of the legislature, and the deaths of several people. While Trump was not directly involved with the riot, he has been accused of contributing to it by consistently refusing to accept the election results, claiming that his opponent's victory was fraudulent, and using inflammatory rhetoric when speaking to his supporters. As a result, officials from both major political parties have called upon Trump to resign, and other avenues to remove him from office have been proposed. At the time of publication, Trump's second impeachment had been mooted but it, and all other events that followed, had not yet happened.

Normal American life, already strained under the COVID-19 pandemic, was dealt another blow by the conflict. Normally planned events continue to be held, but the shadow of current events impacts everything. This comic depicts one such event, a news conference hosted by the State Apple Growers (of an unspecified state). This group apparently had a scheduled meeting to discuss apple variety standards, but their meeting was instead dominated by discussions of events in government, resulting in them issuing a formal statement

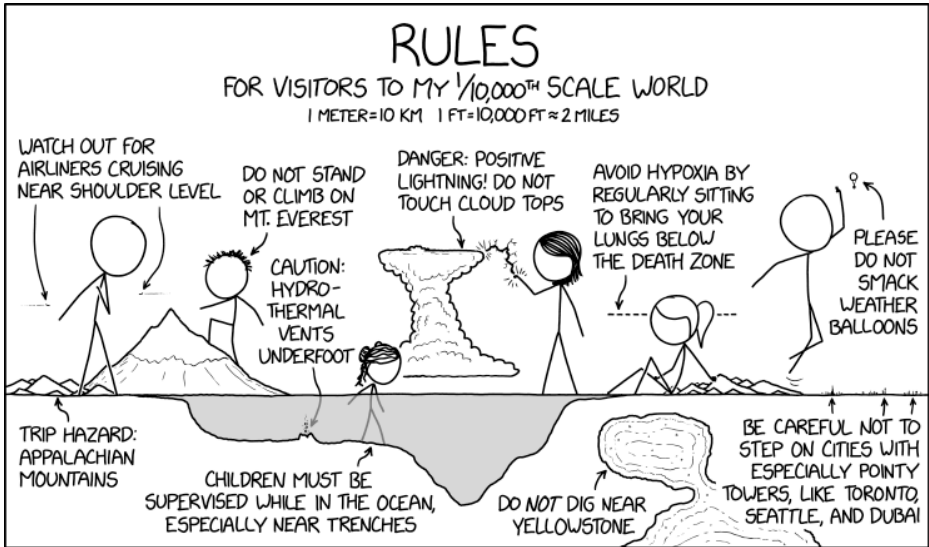
calling upon President Trump to resign. This statement obviously has nothing to do with apples,[citation needed] and when pressed, the spokesperson makes generic statements in favor of apples, but points out that they're too distracted by more urgent matters to focus on their normal jobs.

This strip appears to be based on a number of private companies and other organizations without specific political missions, which nonetheless felt the need to respond to the event. Famously, both Twitter and Facebook banned the president from their platforms in the aftermath. The events of the strip are reminiscent of Signature Bank and the National Association of Manufacturers calling on Trump to resign. Many national brands released statements of condemnation and announced plans to cut political contributions for legislators who voted against certification of the election results. The joke appears to be that even small and local organizations feel compelled to weigh in on an issue of this significance, even though their influence in the matter is likely minimal. Cosmic Crisp, mentioned in title text, is a variety of apples developed in the Washington State University that has been on sale since 2019, amid a large marketing campaign. The implication of the title text is that the people involved are in fact, very interested in and concerned with details of apple cultivation and marketing, and hope to return to a state in which they they can focus on those. But the more immediate draw of events makes it difficult to focus on what they usually like to talk about.

Beret Guy is shown to be a member of the State Apple Growers' Association; in 2209: Fresh Pears, he sells "fresh pears" (so fresh, he doesn't even plant seeds until a customer pays for one) and expresses an interest in growing apples, and evidently has either figured out robotic grafting or chosen another approach (or maybe, given his usual eccentricity, he is only a member of the Association as an aspiring apple grower). This is one of very few comics with Beret Guy where he is not really doing anything, although this is also a weird turn of events that the Apple Growers discuss Trump. However, usually Beret Guy is not interested in real-life problems.

#2411: 1/10,000th Scale World

January 13, 2021



OCEAN PLAY AREA RULES: No running, no horseplay, no megatsunamis, and no trying to pry the wreck of the Titanic off the bottom.

Explanation

This comic is the first in the Scale World series. It was followed in the next release in the same week by 2412: 1/100,000th Scale World.

Large objects (cars, airplanes, etc.) are often reproduced as scale models, which are proportionally smaller physical models of the original objects. The scale of such a model is typically expressed as the ratio of the size of the model (the first number) to the size of the original object (the second number). For example, a 1/10,000th scale model means that 1 meter in the model represents 10,000 meters in the original object. The same applies to maps and globes. What Randall has here, though, is neither a map nor a model but a seemingly complete copy of Earth, at a 1:10,000 scale. Various features and warnings are labeled.

Miniature parks, also known as model villages, are tourist attractions around the world of a scale between 1:9 and 1:72. For example, the finale of the movie *Hot Fuzz* features a battle amongst a miniature of the streets and buildings seen so far in the film. Normally a miniature park would feature a representation of one geographical location rather than a geologically/technologically accurate depiction of our current planet. Whether or not Randall is aware of it, the reputed largest outdoor relief map in the world is set out at a horizontal scale of 1:10,000.

Real-world phenomena are reproduced at scale, for humorous effect. A real 1/10,000th scale "Earth" would have a diameter of less than a mile, and a surface area of around 2 square miles, the approximate dimensions of a medium-sized asteroid. On such an object, constrained by known physics, there would be no air, standing water, weather, or large magma bodies, and any sort of rough-housing would irrecoverably catapult the visitor into space.

Normally in a miniature model, most warnings try to prevent the visitors from accidentally doing something cataclysmic to the model. Likewise, the "ocean play area rules" in the title text tell visitors not to create any megatsunamis, which could conceivably be induced by a cannonball dive. But as digging seems to be discouraged mainly where it causes volcanoes to break out, the visitors seem to be given far greater freedom than usual.

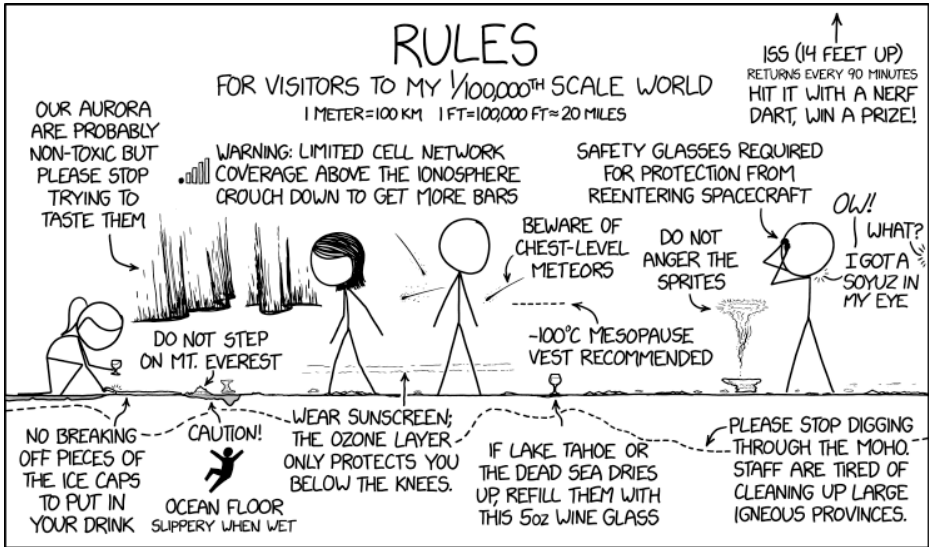
Visitors are also instructed not to try to pry the model of the wreck of the Titanic off the ocean floor. In our world, the wreck is at a depth of 12,500 feet, which would be 1 foot and 3 inches in Randall's model world. The Titanic was over 882 feet long, but the ship split in half as she sank, and now lies in two pieces about a third of a mile apart. Randall's model would have two pieces about a half-inch in size separated by about two inches. If the models are rusted and sunk in mud just like the real wreck is, trying to pry them loose would certainly damage them, but all of Randall's other rules seem to be about preventing harm to guests, not preventing damage to the model, so maybe he just doesn't want guests

bending over and exerting themselves in the water where they could slip, submerge their faces, and be at risk of drowning.

Scale models, and the problems with them, were the subject of 878: Model Rail. In general, illustrating relative scale is a recurring subject on xkcd. This comic is also somewhat reminiscent of 941: Depth Perception.

#2412: 1/100,000th Scale World

January 15, 2021



The floor should be slightly curved, but we haven't figured out artificial gravity yet, so for now we just added a trace intoxicating gas to the air that messes with your inner ear and gives you a sense that the ground is tilting away from you.

Explanation

This comic is the second in the Scale World series. It follows directly from the previous release in the same week 2411: 1/10,000th Scale World and it was followed less than two weeks after by 2417: 1/1,000th Scale World.

Randall has another seemingly complete scale model of Earth, this time at a smaller scale of 1:100,000 – that is, 1 meter in this scale world represents 100,000 meters in the real world. (This is one tenth the size of his previous scale world.) Again, real-world features and phenomena are depicted at scale and labeled with warnings. Details on the various remarks are in the table below.

The title text states that the floor should be slightly curved. In fact, given that the model in the comic is about 10 meters long, it represents about 1000 km of Earth, which spans about 9 degrees of a great circle. Therefore, if the model wasn't larger than the part shown in the panel, its edges would have a very noticeable slope of 4.5 degrees. What's more, the note that artificial gravity hasn't been invented reveals that the scale worlds are nothing more than a mundane model, rather than some supernatural phenomenon that allows giants to roam about the surface of the Earth. Instead, intoxicating gas is added to the air to make people feel like the ground is curving away.

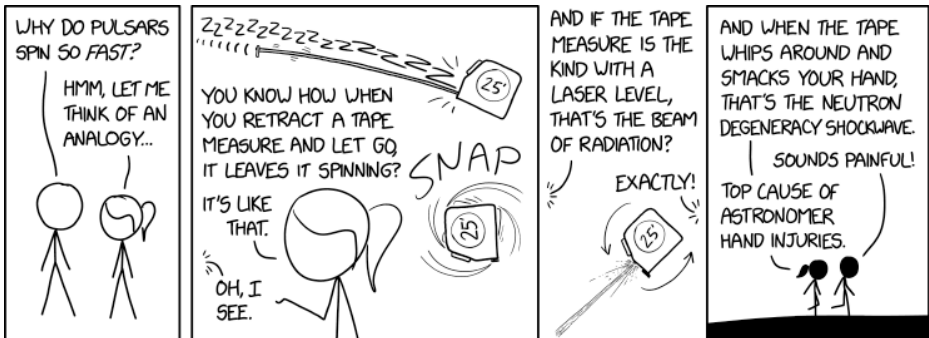
Curved floors were also mentioned in 2632: Greatest

Scientist.

Table[edit]

#2413: Pulsar Analogy

January 18, 2021



The #2 cause of astronomer hand injuries is trying to do vector math when the second axis points off to the right.

Explanation

Pulsars are a kind of old, shrunken, fast-spinning star. They are usually neutron stars. They no longer shine in all directions, but instead produce beams of radiation out of their magnetic poles, which blip by us in rapid pulses as they spin.

Ponytail, an astronomer in this comic, explains a pulsar's fast rotation with an analogy about a tape measure retracting. The analogies that Ponytail picks are incredibly poor ones, as seen in 2094: Short Selling.

Since the analogy does result in something that spins, the reader might think that, while they don't immediately see how it helps in understanding pulsars, they're willing to reserve judgment to see what is then done with the analogy; Cueball's response may suggest this sort of wait-and-see attitude. However, the analogy is likely to be useless or misleading, as the tape measure starts to rotate because the retracting tape is not moving only in a radial (in/out) direction. As a star collapses into a pulsar, its natural rotation rate is greatly amplified by its shrinking moment of inertia.

Further elaborations of the analogy, rather than clarifying matters, are successively more surreal. More misleading than the tape-measure is the idea of a laser measure being "exactly" like the emissions of a pulsar, which, although both pulse, are produced in entirely different ways and are at best simply helping the mind

hold the concept.

When a tape measure retracts, the part of the tape outside the tape measure is not going directly towards the tape measure's center but rather towards a hole in the side. This means the tape possesses some angular momentum relative to the tape measure. In addition, when the tape measure retracts, the part of the tape inside the tape measure rotates around a spool (which pulls the part of the tape outside the tape measure inside), so it also has angular momentum relative to the tape measure. When the tape is completely retracted, the tape can no longer rotate relative to the tape measure. Because of the conservation of rotational momentum, the tape measure will start spinning at this point.

While pulsars also rotate quickly due to the conservation of angular momentum, the exact mechanism is completely different. Pulsars are formed when stars collapse due to no longer performing enough fusion to produce enough heat and energy to cancel out gravity. This causes the star to contract, which causes its mass, on average, to be closer to its axis of rotation, which causes the rotational inertia (also called the moment of inertia) to decrease. If the star's angular velocity stayed constant, this would cause the angular momentum to decrease, so the star's angular velocity must increase in order to offset the decrease in rotational inertia, i.e. the star (which is now a pulsar) spins faster. This is demonstrated here. This method requires an initial rotation, which comes from the star. (The star's rotation comes from the dynamics of the gas cloud which forms the solar system

in the first place.)

Some tape measures have a built-in laser line level and others have a built-in laser rangefinder. Pulsars emit electromagnetic radiation out of their magnetic poles, which is similar to a laser, but unlike the laser of a tape measure, the pulsar beam is emitted through the axis of the magnetic field. The pulsing nature of a pulsar comes from when the axis of rotation is not precisely aligned with the axis of the magnetic field, and the location of the viewer as the beam sweeps by. In the tape measure analogy the beam is at a right angle to the axis of rotation, so as long as the viewing angle isn't parallel with the rotation axis, the viewer would see the laser increase and decrease periodically as it the rotating tape measure points towards or away from the viewer.

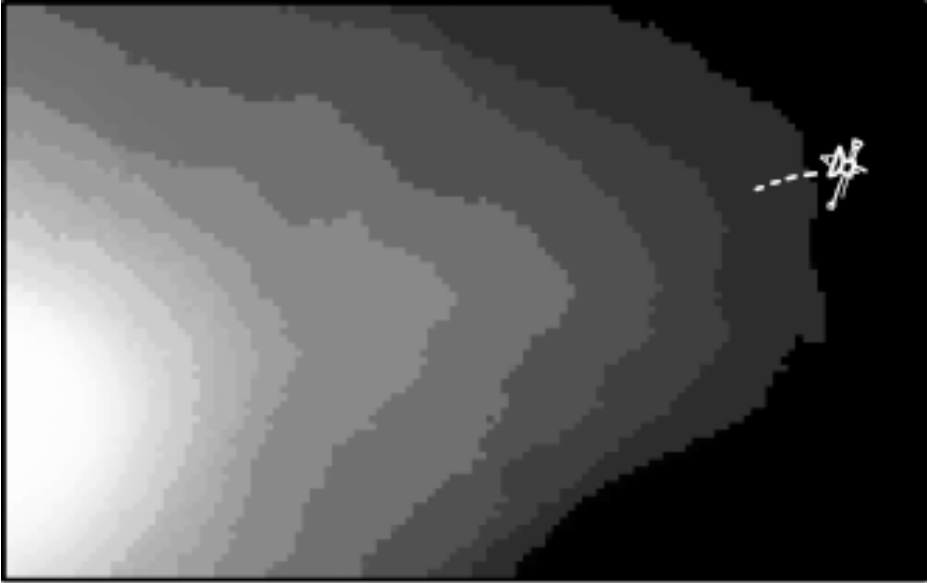
While pulsars do demonstrate incredible starquakes and rotational glitches, neutron degeneracy is part of the mechanisms in which they are originally formed. During the formation of a neutron star, usually in the form of an initial inward implosion, the neutron degeneracy (basically the impossibility of neutron of occupying the same space because of fundamental constraints in physics that are studied by quantum mechanics) stops the implosion and redirects the shockwave outwards, thus producing a Supernova explosion. The analogy is with a tape measurer that hits a hand (the constraint) during its rapid rotation due to its retracting tape (the implosion) thus redirecting part of the energy towards the hand (the supernova energy is redirected outside).

However, astronomers do not usually let go of laser tape measures frequently, so they are probably not the top cause of any type of hand injuries, contrary to what Ponytail said.

The title text mentions the right-hand rule in three-dimensional space. In a typical 3D coordinate system the Y-axis will point counterclockwise to the X-axis when looking down from the positive Z-axis. In academia, students are often taught to remember a number of mathematical conventions by using their actual physical right and left hands to align the axes. When the axes are in a different order, the left hand can be used instead of the right, but there are a number of common operations in engineering and physics that use the cross product in systems where the first axis might point in absolutely any direction relative to the viewer. Using the hand rules, the thumb is aimed along the first axis, the forefinger along the second, and the middle finger along the third — all at ninety degrees. So, when the first axis points off to the right, the right wrist is torqued to its full extension to make the thumb point that way while the other two fingers don't. During exams, students can be seen performing this feat. People who learn cross products early in their life may develop other approaches for remembering these things, that don't stretch the hands as much, but then adopt the common approach once taught it. This rule has been previously mentioned in 199: Right-Hand Rule.

#2414: Solar System Compression Artifacts

January 20, 2021



MILESTONE: VOYAGER HAS PASSED THROUGH
THE STREAMING VIDEO COMPRESSION ARTIFACTS
THAT MARK THE EDGE OF THE SOLAR SYSTEM

Most of our universe consists of dark matter rendered
completely undetectable by our spacetime codec's
dynamic range issues.

Explanation

Voyager 1 is a space probe launched by the United States in 1977. Originally designed to study the outer planets of the Solar System, it is now several decades into an extended mission beyond Neptune (see #Trivia). The Voyager probe has made history for passing many milestones of our solar system.

When images are compressed by a lossy compression format (e.g. JPEG), visual artifacts are created. Randall here is suggesting that the probe has passed the artifacts as if the artifacts were an actual feature of the solar system rather than a consequence of our technology. The banding lines he has drawn are commonly seen in old images with low bit depth.

The 'solar system' in the snapshot appears to be a 4-bit greyscale-plane at a more pixelated level than the image given. It contains 16 'banded' levels from the brightest (closest zones, within this image, to the Sun) to darkest (the furthest illustrated expanses, including interstellar space), with irregular or non-trivial transitional edges but no obvious or dominant dithering/speckling or 'noise'. The Voyager image (and track) is overlaid in a white 'line drawing' format.

Each apparent pixel in this low-res rendering is approximately 1 AU^2 , where 1 AU (astronomical unit) is the distance from the Sun to the earth. The Sun is off the left side of the image by about 30 pixels, meaning that of

all the planets in the solar system, only Neptune would have an orbit that is within the image at all (at the left edge). The heliosphere is 120 AU from the sun, in the direction that Voyager 1 is travelling: Voyager crossed that milestone in August 2012. At time of publication Voyager was just over 150 AU from the Sun, as shown in the image.

Continuing on its course at 38,000 mph, or 3.6 AU/year, Voyager will reach the outer edge of the Oort cloud, the edge of our solar system, in about 300 years.

The title text refers to 'our spacetime codec', suggesting a representation of reality itself as a series of ones and zeros. If empty space is the darkest possible thing that can be represented--which may be the case when only 16 levels are available (see above)--then it is possible that dark matter is so dark that it cannot be represented: it would require a negative number, which is not available. This is the dynamic range issue mentioned.

The title text may also be a pun on the term "Render", as the codec's issues would both make cause the dark matter to be undetectable and, in the metaphor of the universe as a simulation, literally fail to render the "pixels" in the dark matter. This is the play on the term "Render" having multiple definitions, both meaning "To cause to become" and being the term in computing for "Transforming (a model) into a display on the screen or other media", as per Wikitionary.

Artefacts are evident in 1683: Digital Data, and

mentioned in the title text of 331: Photoshops.

#2415: Allow Captcha

January 22, 2021



THEY'RE GETTING SMARTER.

To prove you're human, please click all the number pairs that appear together in your Social Security number.

Explanation

Captcha is designed to prevent automated access on websites by posing challenges that humans can easily solve but that spambots and other automated programs cannot solve. The original version (used in 632: Suspicion) asked users to identify text that was rotated, warped, or otherwise modified in order to make it more difficult for automated programs to solve. Once automated programs got good at that, new captchas were put out that exploited the fact that computers tend to be bad at image recognition, e.g. asking the user to select only images that contain cats from a grid of images of cats, dogs, and other objects (used in 1897: Self Driving). This captcha appears to combine the two methods—with the additional hurdle that in order to pass the captcha, users must be able to not only read but also understand (i.e. know the definitions of words). However, if the goal is to allow humans but not computers to pass (although, as the next paragraph will describe, it is not the goal), this is not a good method of differentiating between the two. Any computer program that can accurately read text (and there are now many programs that can do so) would know which words start with 'A' and would be able to look up the definitions (including parts of speech) online, so this would not be effective as a captcha. Humans on the other hand, would often get confused between "ale" and "ail" or between "allot" and "a lot". The English language has no distinction between nouns and verbs by spelling, only

grammatical usage, and many words in English are both nouns and verbs, depending on context and placement.

In reality, however, the window is merely disguised as a captcha in order to trick human visitors into allowing the website to install "a helper tool", which may be malware, on their computer. The top of the window uses a similar shade of blue to the current version of reCAPTCHA (currently the most common brand of captcha), the prompt includes the phrase "to prove you're human", and the grid is similar to the grid used by reCAPTCHA. However, positioned to appear to humans as two reCAPTCHA boxes is a window asking viewers whether they want to allow or deny the website's request to install the supposed "helper tool". The idea is that because "allow" is a verb beginning with the letter A, human visitors would click on what they think is the box with the word allow in it but actually allow the website to install potential malware on their computer. The window attempts to disguise this by formatting many of the words in boxes as buttons and including other text in smaller font on other boxes. In addition, the captcha may be intentionally difficult so that users will be too distracted by wondering whether ale is a verb to process the meaning of the request.

It should be noted that simply tricking humans would not necessarily be enough to install malware on their computer. First of all, while a person can select any part of a grid box in order to select that box, only clicking on the actual button that says allow will allow malware onto the computer. If a person clicks on another part of the

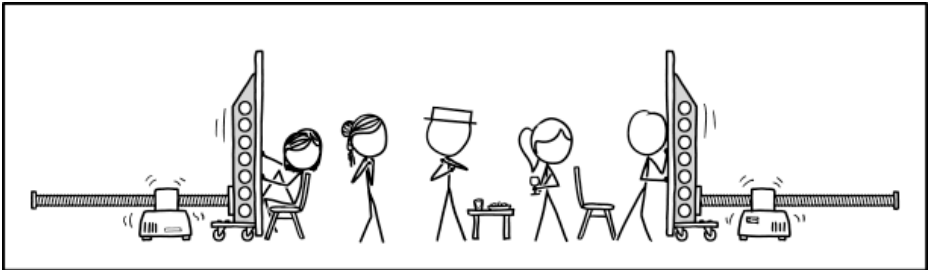
supposed box, nothing will happen, so the person will likely take a closer look in order to see why the window is not being selected and then possibly realize that this is a trick as a result. Further, the website would likely not be able to specify where the permission window appears, so would not be able to fit it into the fake reCAPTCHA. In addition, the user's computer may have an anti-virus software that will prevent the computer from executing malicious code downloaded by the website. Or in order for the user to install software, a second window may pop up requiring the user to type in an administrator password, which will likely startle the user.

Shady websites often use similar tactics to trick you into allowing notifications, including saying "Please allow notifications to confirm you are not a robot". This comic combines that with a traditional reCAPTCHA to try and trick savvy users too.

The title text is another trick reCAPTCHA which is trying to make you give out your social security number by clicking the pairs of numbers that appear in your Social Security number. A social security number is a form of identification used in the United States, originally used for the Social Security Administration. Over time, this number has become a type of national identification number, so stealing these numbers would allow a scammer to commit identity fraud.

#2416: Trash Compactor Party

January 25, 2021



I'M PLANNING A TRASH-COMPACTOR-THEMED
PARTY FOR WHEN THIS IS ALL OVER SO WE CAN
GET USED TO STANDING NEAR EACH OTHER AGAIN.

What an incredible smell you've discovered.

Explanation

This comic is another in a series of comics related to the COVID-19 pandemic.

Randall is planning a party for when the pandemic is under control and it will again be acceptable to meet with people in close proximity and without a face mask or other kinds of protection.

But he has realized that after more than a year, where social distancing has been a thing, it will be difficult to get people to voluntarily move closer than 1-2 m from each other.

Thus to break the ice, and the social distancing, his party will have a theme - it will be a Trash Compactor Party. So he plans to install two moving walls on either side of the party room, which will slowly move together pressing people closer together. It is supposed to be a theme party, so the walls are not supposed to crush people in the end,[citation needed] but force them to get much closer than one meter apart.

In the comic Randall shows how people might react to this after more than a year without being close to anyone not from their own family/corona bubble.

Cueball and Megan are trying to push each of the walls of the trash compactor back in order to prevent it from pushing them closer to the three other people. Two of the other attendees, Hairbun and White Hat appear to

be anxiously shying away from the inexorably increasing proximity of both of their neighboring guests, as they hold their arms nervously and protectively around their chests and necks. Thus reflecting the common current trend for many normal people to maintain increased personal space when meeting or passing other people active, compared with the pre-COVID era. Randall's claim is that this will not just go away because the restrictions are completely lifted if the pandemic comes under control. Ponytail is the one that seems least concerned; she even stands with a wine glass in her hands. She is looking at Cueball, maybe amused at the other people's reactions to a now safe situation.

The title text references a high-profile instance of the trope from the original Star Wars film (later retitled Star Wars: Episode IV — A New Hope). Han Solo utters this quip shortly after he and several other main characters bail out of a firefight and land in a trash compactor. The walls then start closing in and, as in the comic, the characters are not enthused about being pushed ever closer together, and seek to push back on the walls before being crushed. Here, the quote also expresses a sense of (a new) hope: since a common symptom of COVID-19 is a loss of smell, the fact that the characters are all able to smell their surroundings suggests that the pandemic is gone.

#2417: 1/1,000th Scale World

January 27, 2021



We're worried that a regular whale will get into a 30-foot-deep ocean trench section and filter-feed on all the tiny whales.

Explanation

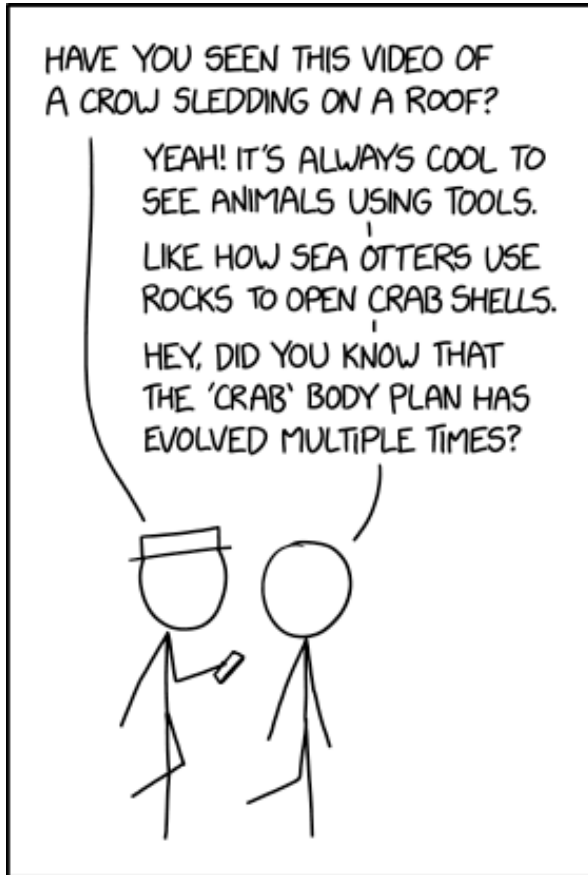
This comic is the third in the Scale World series. It came out less than two weeks after 2412: 1/100,000th Scale World.

Yet again, Randall has a seemingly complete scale model of Earth, this time at a larger scale of 1:1000 – that is, 1 meter in this scale world represents 1000 meters in the real world. (This is ten times the size of Randall's original scale world.) Again, real-world features and phenomena (such as several underground neutrino detectors) are depicted at scale and labeled with warnings. Several of the warnings point out humorous consequences of the scale, such as non-scaled goldfish eating scaled-down blue whales. Other than the usual *homo sapiens*, the introduction of non-scaled animals into the scaled world (with consistently humorous consequences) is an addition to the earlier comics of the series.

Table[\[edit\]](#)

#2418: Metacarcinization

January 29, 2021



REGARDLESS OF THE STARTING TOPIC, ANY CONVERSATION WITH ME EVENTUALLY CONVERGES TOWARD CARCINIZATION.

Scientists still don't know how marine biologists manage to so consistently bring up whalefall ecosystems, when relevant conversational openings are so few and far between.

Explanation

The comic strip opens with a conversation between White Hat and Cueball as they are walking together. White Hat asks Cueball if he has seen a video of a crow sledding on a roof — presumably this one, or one of its later viral reposts. (Animals sledding seems to be a thing lately). In this case, it is a hooded crow. Cueball remarks that it's a cool example of tool use by animals, a sign of intelligence (which corvids [Corvidae; the crow family], including crows, ravens, and jackdaws, are famous for). He then points out that sea otters use tools too, namely using stones to crack open crab shells.

This in turn leads him to bring up the fact that the 'crab' body plan has evolved multiple times, a phenomenon known as carcinization, previously discussed in 2314: Carcinization. In that strip, Cueball turned into a crab shortly after hearing about carcinization, so perhaps White Hat will likewise be transformed momentarily. This conversation is thus called "metacarcinization", as other things unrelated to evolution converge on the topic of crabs.

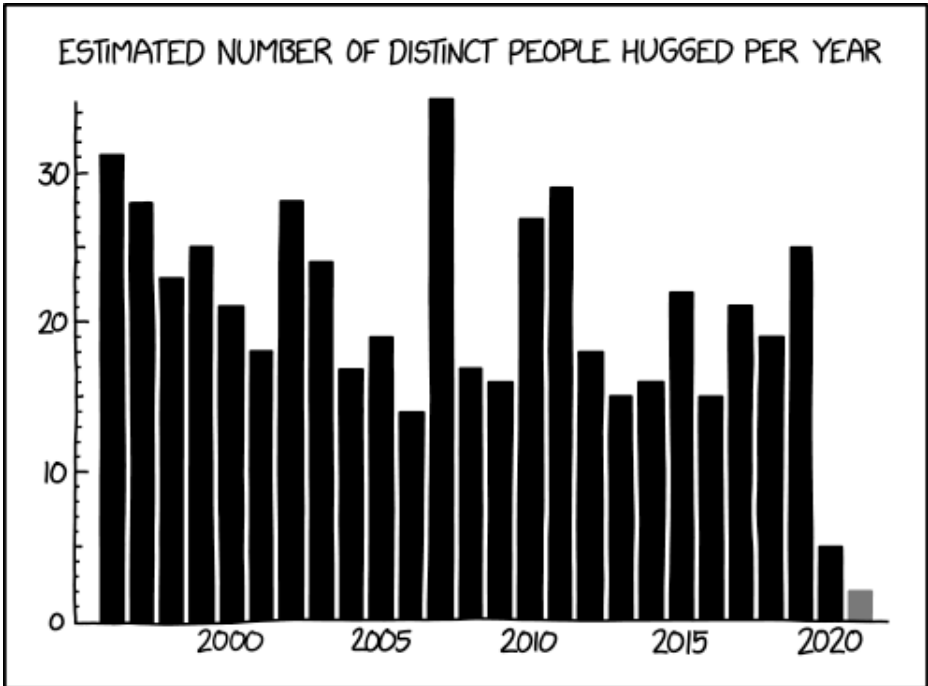
The conversation serves as an example of a wiki walk, where a conversation naturally diverts from the original topic into a seemingly unrelated topic through a series of logical associations. Although a sledding crow has little to do with carcinization in and of itself, the conversation has managed to bridge the two topics through intermediary steps (crow using a sled, animals using tools

in general, otters using stones to open crabs, crab evolutionary process).

In the title text, Randall jokes that marine biologists have a similar tendency to bring up whalefall (or "whale fall") ecosystems, which arise whenever a whale's carcass falls onto the deep ocean floor and are thought to provide "stepping stones" for species migration across the generally barren seafloor. Such occurrences are relatively rare, perhaps occurring once every few miles on whale migration routes, but they happen anyway, much like conversations about them. Another example of scientists tending to bring up facts from their field of study can be found at 1610: Fire Ants, and Randall often brings up the fact that birds evolved from dinosaurs.

#2419: Hug Count

February 01, 2021



I've never been that big of a hug person, but it turns out I'm not quite this small of a hug person either.

Explanation

This comic is another in a series of comics related to the COVID-19 pandemic.

The comic displays a bar chart showing the number of Individuals Randall has hugged per year, spanning from 1996 to 2021, and goes up to 35 individuals hugged in 2007. The apparent spike in the estimate for 2007 may have been chance or may have been a known social event that Randall remembers, such as a family reunion or anticipated parting from a social group (such as a school or job from which he left), where he hugged many people he otherwise would not have hugged. While it varies a decent amount for the first 24 years, it drops sharply in 2020 and goes even lower in 2021. However, it should be noted that 2021 (at the time of the comic) had just begun, which is why the final bar is grey. It seems he is down to only two people hugged in 2021, one of which is most likely his wife. In 2020 he managed 5 different hugs, but the extra three may have been before the onset of COVID-19 precautions in the US.





































This is because in 2020 when the pandemic happened, everyone had to social distance and avoid contact with strangers. This was a widely used method of slowing the spread of COVID-19. People are asked to not closely associate with those outside a very limited 'bubble' or even isolate themselves in their own household. As such, people have had less physical contact with each other since the beginning of this pandemic, including hugs.

No explanation is given for the variations year-to-year preceding 2020, and much of it may be random walks. However, one can see a major spike in hug levels in 2010 and 2011; Randall's wife was diagnosed with cancer in late 2010 (see Category:Cancer). Loved ones of those with cancer tend to receive much compassion from others, and compassion tends to beget hugs.

The title text states that, while Randall isn't very big on hugs, he too desires hugs. It plays on the common phrase "I'm not too big of an (x) person", which is used to indicate that someone isn't extremely fond of said activity. One could then infer the person is not fond of the activity at all, though in this case, he indicates his desire for hugs is non-zero, as presumably demonstrated by the frequency being now less than even he would prefer.

#2420: Appliances

February 03, 2021

	TOASTER	DISHWASHER	MICROWAVE	WASHING MACHINE	STOVE/OVEN	DRYER
MAKE TOAST						
WASH DISHES						
COOK A FROZEN DINNER						
WASH CLOTHES						
COOK EGGS						
DRY CLOTHES						

If you had an oven bag and a dryer that runs unusually hot, I guess you could in theory make tumbled eggs.

Explanation

This comic shows a confusion matrix of the applicability of various household appliances to different tasks. Green indicates an excellent performance, yellow not ideal, but usable, and red dismal or destroyed. The diagonal is green as it shows the tasks done by the machines they are supposed to be performed by. See table below. The comic is similar to 1890: What to Bring, 2813: What To Do, and 2963: House Inputs and Outputs, but those comics do not use yellow or another intermediate color.

Plain salmon fillets can be easily cooked in a dishwasher, so it is marked "cooked", and thus "cook a frozen dinner" is only yellow on the dishwasher entry, rather than full red. This might also apply to most other types of fish (trout, which is evolutionarily a type of salmon, was a prior subject for this process), as commercially-prepared frozen dinners tend to be breaded white fish such as cod, mackerel, smelt, etc. for price and logistical reasons (retaining their taste and firmness through the cooking, freezing, thawing and reheating processes). That's if it is not a recipe built around fish, as with a tuna casserole, in which case it is probably entirely subject to whether the whole of the pre-cooked and frozen meal can be sufficiently defrosted and raised to a safe and palatable temperature.

The stove/oven has three green as it can also cook a microwave frozen dinner, although slower, and can toast bread, again slower than the toaster. It is by far the

machine that has the fewest red entries, only one, as it cannot wash clothes. It can also not clean dishes, but it might sterilize them, thus that entry is yellow. It may actually dry the clothes, but is liable to burn them and is therefore yellow.

The microwave oven can also cook eggs, thus it has two green, the only other than the stove/oven with more than one green.

The toaster and the washing machines are the only ones without any yellow, and with only one green, for making toast/washing clothes - they are thus the appliances with the fewest other potential uses (zero). The washing machine will at least not destroy the clothes if you try to dry them, but it has the opposite effect, thus still red. The toaster will potentially just make the dirt on the dishes burn harder, and additionally appears to have melted the tines of the fork.

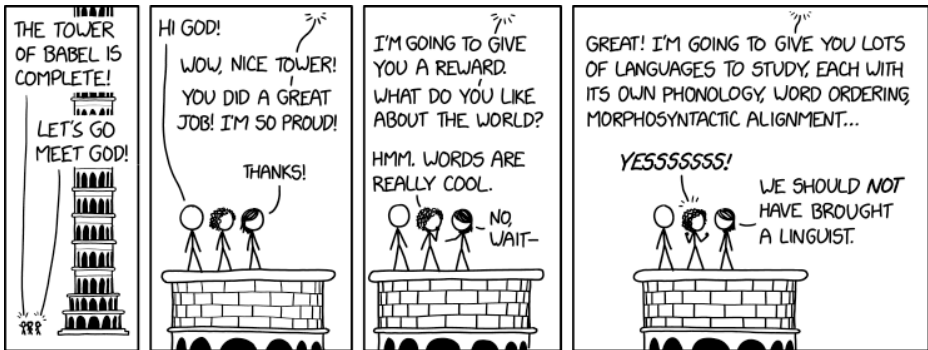
The title text mentions that it would be theoretically possible to cook eggs in a dryer, but it is not a common use for a dryer.[citation needed] The joke is that it is not called scrambled eggs but tumbled eggs. It also mentions that the dryer has to become hotter than usual for a dryer (maybe dangerously hot for the clothes for it to work). And then the eggs should be cracked and put in an oven bag, that really needs to be tight and well zipped.

The table displays a diagonal line of greens from top-left to bottom-right, as is typical with a table where the first row option is deliberately compatible with the first

column option, the second row with the second column, etc. What is perhaps more interesting is where the non-diagonal greens appear (and, to some extent, the yellows), indicating appliances or uses that are more flexible and range beyond being of a mere one-trick pony.

#2421: Tower of Babel

February 05, 2021



Soon, linguists will be wandering around everywhere, saying things like "colorless green ideas sleep furiously" and "more people have been to Russia than I have," and speech will become unintelligible.

Explanation

The story of the Tower of Babel is the Biblical explanation for the existence of different languages in the world. In the story, humans endeavour to build a tower reaching heaven. Their arrogance angers God and prompts him to sabotage the project. He does this by "confounding their speech" (commonly interpreted as giving everyone their own language), inhibiting their ability to work together.

In this retelling, however, the events are the same, but the motives changed. God is pleased with the tower, and promises to create a diversity of languages, not as a punishment, but as a reward for the member of the party who finds words interesting. Megan seems to recognize the potential issues this would cause, but the word-loving woman is enthusiastic. This plays on Randall's various geeky interests, recognizing that complexities of the world, which frustrate many people, are a source of great joy and interest to others. A world with only one language would make travel and global communication much easier, but for those with an interest in linguistics, it would be deeply limiting, as there would be only one language to study. The party that ascends to the top of the tower consists of Cueball, Megan, and Gretchen McCulloch as the curly-haired woman, who has appeared before in 2250: OK/okay/ok and 2381: The True Name of the Bear.

Phonology is the study of the sounds used in a language

or dialect, or of the systems that languages use to organize sounds. For example, English has the words "light" and "right", indicating a distinction between /l/ and /r/, but other languages, such as Japanese, do not, resulting in the (in)famous stereotype. On the other hand, English does not make a distinction between /u/ and /y/, while French does, having words such as "le but" (the goal) and "le bout" (the tip). Word order is the study of order of the parts of a language, e.g., the subject, object, verb, and other modifiers. English uses the subject-verb-object order ("She loves him"), but other languages use subject-object-verb ("She him loves") and other permutations of these orders.

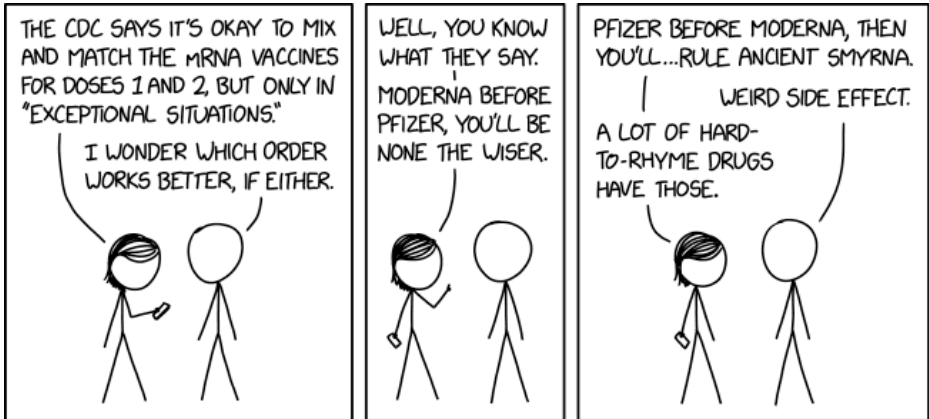
Morphosyntactic alignment is the relationship between the "roles" in a sentence, and how they relate to transitivity. The vast majority of world languages, including English, use nominative-accusative alignment. In nominative-accusative languages, the subjects of transitive verbs (verbs with objects) and the subjects of intransitive verbs (verbs without objects) are treated the same, and differently from the objects of transitive verbs. For example, "She sees him" and "She runs" use the same word "she". However, other forms exist like ergative-absolutive alignment, where the subject of an intransitive verb matches the object of a transitive verb ("She sees him" and "Her runs"), transitive alignment, where the subject and object of a transitive verb are the same and different from the subject of an intransitive verb ("Her sees him" and "She runs"), or split-S and split ergativity, where it follows nominative-accusative or

ergative-absolutive based on context. For example, if it depends on animacy, you could have "She (the person) runs", but "Them (the trees) fall".

The title text expands the joke by suggesting that the miscommunication caused by the Tower of Babel is not due to language barriers, but instead because linguists have created intentionally meaningless sentences to illustrate points about grammar and identifies two famous examples of such. "Colorless green ideas sleep furiously", coined by linguist Noam Chomsky in 1957, is an example of a sentence that is structurally correct but contains paradoxes and meaningless comparisons: Something cannot be both colorless AND green (see Invisible Pink Unicorn), ideas do not sleep, and sleeping generally is not done furiously.[citation needed] That said, the sentence "colorless green ideas sleep furiously" is so well known in linguistics that a competition to make the sentence meaningful was held in 1985 and attracted a number of entrants. "More people have been to Russia than I have" is an example of comparative illusion. The idea conveyed by the sentence may seem to be clear at first, but upon deeper analysis it has no well-formed meaning and is open to interpretation. The literal interpretation appears to be "I do not own/have in my household as many people as those who have been to Russia."

#2422: Vaccine Ordering

February 08, 2021



You know what they say: mRNA-1273 before tozinameran, you'll have to slay a banshee in a catamaran.

Explanation

This comic is another in a series of comics related to the COVID-19 pandemic, specifically regarding the COVID-19 vaccine.

Two COVID-19 vaccines have been approved in the United States (one from Moderna, the other from a joint venture between Pfizer and BioNTech). Each of these vaccines require 2 doses, taken 3-4 weeks apart.

Megan is reading an article on her phone to Cueball. A report from the CDC says that it's possible to get effective immunity against COVID-19 when mixing mRNA vaccine doses from Pfizer and Moderna, but that this practice should not be the norm. The report in question can be viewed [here](#); it stresses that mixing the vaccines is acceptable only in exceptional circumstances, such as "when the first-dose vaccine product cannot be determined."

Cueball wonders whether the order in which you receive the vaccines matters. Megan then attempts to create mnemonic devices to help them remember which mix-and-match strategy is best for the mRNA vaccines (e.g., "Beer before wine and you'll feel fine; wine before beer and you'll feel queer"). She "concludes" that receiving the Pfizer vaccine after the Moderna one will be just as effective as having two doses of either, but that having the Moderna vaccine after Pfizer's will lead to the patient becoming the ruler of an ancient city. Megan

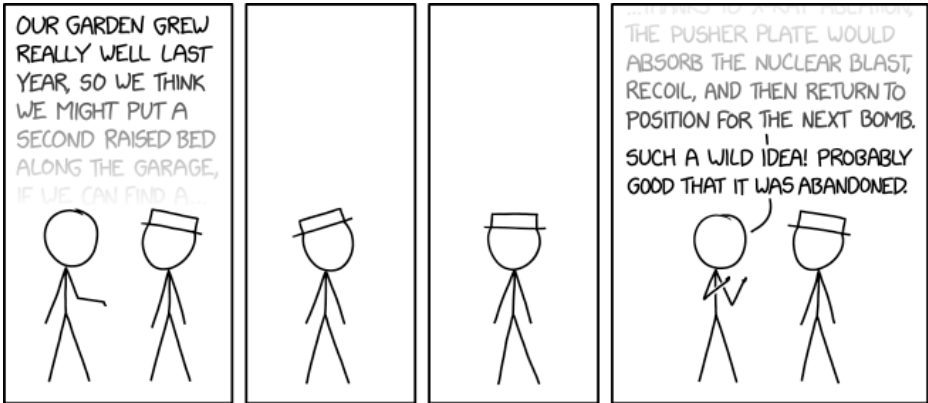
might mean that the patient will be literally transported back in time, as she and Cueball (and Black Hat) were in 2321: Low-Background Metal. The apparent truthiness of these mnemonics might be attributed to the rhyme-as-reason effect, a cognitive bias that is often misleading - very much so in this case. Megan succeeds by rhyming "Pfizer" and "wiser," but struggles with finding a rhyme for "Moderna," settling for Smyrna, an ancient city located in what is now Izmir, Turkey. Two equally ridiculous rhymes could be "Pfizer before Moderna, you'll have a broken xiphisterna (plural of xiphisterum, or the xiphoid, a small triangular extension of the sternum)" or "Pfizer before Moderna, you'll be attacked by sharks of genus Sphyrna (a hammerhead shark)".

A side effect of a drug is an effect incidental to the intended purpose of the drug. Side effects can be positive or negative, though in vaccine trials the greater concern is usually about negative side effects. Becoming ruler of an ancient city that is now only a historical ruin would certainly be an unexpected side effect.[citation needed]

The title text continues the theme of difficult rhymes, using the full names of both the Moderna vaccine drug (mRNA-1273, rhymed with banshee) and the Pfizer one (tozinameran, rhymed with catamaran).

#2423: Project Orion

February 10, 2021



IF YOU TEMPORARILY TUNE OUT WHILE A PHYSICIST IS TALKING, WHEN YOU TUNE BACK IN THEY'LL BE TALKING ABOUT PROJECT ORION.

If you tune out again, when you tune back in you'll be hearing about dusty plasma fission fragment rockets.

Explanation

White Hat and Cueball are having a conversation. In the first panel, Cueball is telling White Hat about his gardening experiences. White Hat tunes out for the middle two panels, and when he starts paying attention again, Cueball is discussing Project Orion.

Project Orion was an ambitious idea, funded briefly by the US government in the 1960s, to launch enormous spaceships into orbit by detonating a series of nuclear bombs below them. The force from the explosions would be absorbed by a pusher plate on the bottom of the rocket, which is the detail Cueball is sharing when White Hat tunes back in. In *Ad Astra*, Roy McBride uses a similar mechanism to get from Neptune back to Earth. It was considered feasible for construction, but abandoned because of the 1963 Partial Test Ban Treaty as well as out of concerns for both cost and the idea of spaceships literally armed with atomic bombs. People probably daydream about this project because it seems like it could provide for rapid and massive entry into space, but it was halted due to the intense danger. We may have sufficient technology to somehow make this safe with extensive additional engineering, but the risk is still so large it has not been pursued.

The fact that physicists' conversations tend to converge towards Project Orion is similar to how Randall's conversations tend to converge towards carcinization in 2418: Metacarcinization. Cueball turned into a crab (i.e.,

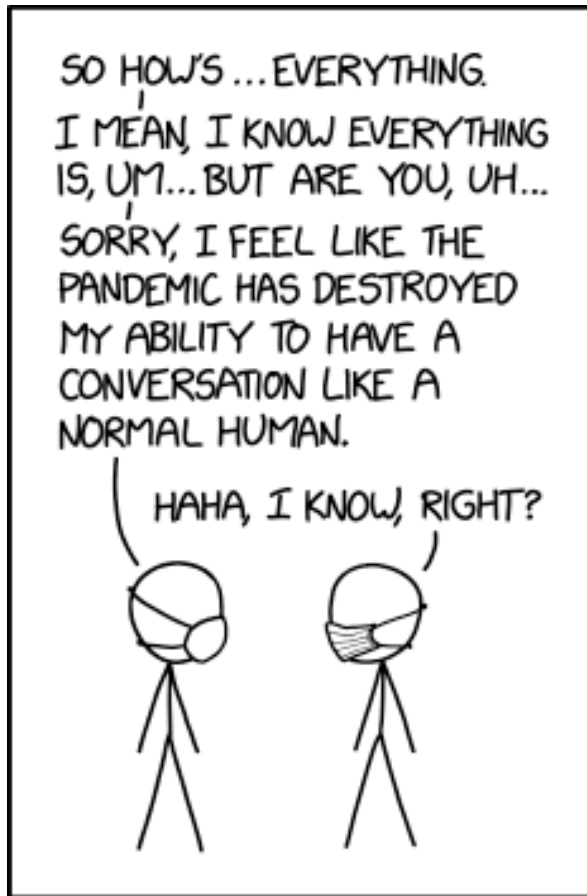
he carcinized) when Megan first told him about carcinization in 2314: Carcinization; hopefully physicists don't do something analogous when discussing Project Orion.

The title text transitions to another cool nuclear rocket technology, dusty plasma fission fragment rockets, which also uses nuclear energy, and would fit well in the 2326: Five Word Jargon collection.

Project Orion has been mentioned before, in 786: Exoplanets, where Beret Guy sums it up as "nuke-riding city ships", and in the what if? article Everybody Out.

#2424: Normal Conversation

February 12, 2021



I'M AT LEAST GLAD I
HAVE THIS EXCUSE NOW.

"I think I'll pass. These days I have a hard time feeling comfortable in crowded bars with loud music and lots of shouting." --me, after the pandemic, but now for a second reason

Explanation

This comic is another in a series of comics related to the COVID-19 pandemic.

Randall/Cueball has shown in many comics the difficulty of making small talk, or having a "normal" conversation, when you spent your developing years developing work skills (comics of this are here), a trait of nerds such as engineers that is frequently used as material in comics. With the COVID-19 pandemic, he feels that others may have difficulty having normal conversations as well, and so this seems to be a "silver lining" for the pandemic. He can now use this excuse instead of having to admit that he has difficulty in social situations (and always has, even before the pandemic). Randall also uses a false but plausible excuse to cover unusual nerd behavior in 1900: Jet Lag. He also uses another excuse which can get him out of life in general in 880: Headache.

In the title text, he shows his dislike, which existed prior to the pandemic, of going to crowded bars. In the future, even after the pandemic passes, Cueball will still have the excuse that the pandemic made him feel uncomfortable in crowded bars due to possible virus spread and that the feeling has persisted past the pandemic. Cueball remarked on his good fortune in 2276: Self-Isolate, as it turns out he has been "practicing social distancing" all his life, but that it has now finally become common practice.

#2425: mRNA Vaccine

February 15, 2021



To ensure lasting immunity, doctors recommend destroying a second Death Star some time after the first.

Explanation

This comic is another in a series of comics related to the COVID-19 pandemic, specifically regarding the COVID-19 vaccine.

This one is another analogy to how mRNA vaccines work, by creating inactive fragments of the virus to prime the immune system to be prepared to stave off the real thing. This is done in response to Cueball's question to the person vaccinating him, "Why would my body attack something it made itself?", using elements of the film *Star Wars: Episode IV* as an analogy.

The analogy starts in the second panel, where the Rebel Alliance has retrieved the Death Star plans, conveyed by Princess Leia to General Jan Dodonna (in *Star Wars*, via R2-D2 and some adventures, but shown as a simple handoff here). The Death Star is a space station the size of a small moon that has the power to destroy planets. In the film, the plans are analyzed to find a weakness in the enemy Death Star and destroy it; however, in this panel, the "Death Star plans" are passed down a line of people until they are interpreted as a construction assignment and are used to build a Death Star. In the analogy, the mRNA in the vaccine corresponds to the plans for the Death Star, the spike proteins (inactive COVID-19 virus fragments) correspond to the benign Death Star itself, and the cellular processes that build spike proteins correspond to the builders of the benign Death Star. Just as merely having the plans on hand led to the Death Star

being built, the mere presence of the mRNA in the cellular environment leads to it being translated, producing the viral protein. Amusingly, as the plans are handed off to the construction crew leader, he replies "Copy that," which is normally just a slang term for "I understand" but here is also a pun that presages his actions.

After Leia's Death Star has been built, it is positioned near a planet/moon. This Death Star is benign: it only looks dangerous and isn't about to actually hurt anyone; the Death Star crew are Rebels, after all, and state that they don't have the laser wired up. The Rebels mobilize to destroy this benign Death Star because it looks like an enemy battle station, evidently not listening to the construction crew's transmissions. Analogously, immune cells cannot think[citation needed] or directly communicate, basing their determination of friend from foe entirely on external chemical signatures. However, the Death Star operators are confused, because they believe Leia (a member of the Rebels) had ordered its construction. The Rebels initially attack the surface of the benign Death Star, without much effect; Leia orders the factories to continue developing torpedoes and ships as they run out, presumably putting an extra workload on the factory workers and tiring them out, or at least diverting resources away from other projects. In the analogy, the Rebels correspond to the immune system's B cells and T cells, which mobilize to attack the spike proteins (the benign Death Star) made as a result of the vaccine, but are often ineffective at first. The body keeps

producing these immune cells, trying many variants (many ways of attacking the benign Death Star) in an attempt to find one that works well against the spike proteins. This results in Cueball experiencing side effects from the vaccine, including soreness and tiredness, and he lies down and rests.

After much effort on the Rebels' part, they find a weakness in the benign Death Star, a "thermal exhaust port" vulnerable to "proton torpedoes" that can destroy the Death Star. Firing a proton torpedo down the exhaust port destroys a Death Star very rapidly, compared to the initial, ineffective frontal assault on the surface. After this benign Death Star is destroyed, Princess Leia allows the fleet to stand down.

Up to this point, the entire thing seems like a comedy of errors, with huge expenditures being made for no apparent reason, due to a simple lack of communication. But during this process, the Rebel Alliance has both built a huge fleet and figured out how to target the Death Star's weakness and destroy it. Later on, when a real, dangerous Death Star approaches the planet (with the apparent intent of destroying it), the Rebels immediately deploy their fleet, target the weakness, and destroy it almost immediately, much to the shock of the Imperial troops, who had believed they were on an invulnerable ship and are surprised by the Rebels' immediate response and overwhelmed by it.

The analogy is that the immune system (the Rebel Alliance) figures out a way to attach to the spike proteins

(attack the benign Death Star) made by the mRNA vaccine; the immune system's antibodies (Rebel planners) now "know" how to recognize and destroy things that have these spike proteins — including SARS-CoV-2 virus particles (real, dangerous Death Stars). Hence, when the vaccinated Cueball approaches White Hat, who is maskless, coughing, and presumably sick with COVID-19, Cueball's immune system is able to destroy dangerous SARS-CoV-2 virus particles because it knows about the virus's spike proteins. This is represented by Cueball not experiencing any suffering from COVID-19, and he goes on his way whistling merrily, perhaps to the tune of The Throne Room/End Title (from the ceremony celebrating the destruction of the Death Star).

It's notable that Cueball continues to wear a mask after being vaccinated. This is in accordance with CDC guidelines, which recommend continuing to wear a mask, practicing social distancing, etc. after getting the vaccine; doctors at CDC "don't yet know whether getting a COVID-19 vaccine will prevent you from spreading the virus that causes COVID-19 to other people, even if you don't get sick yourself." None of the vaccines available as of when the comic was posted are 100% effective at preventing infection, with the best ones about 94% effective at preventing symptomatic cases, but all vaccines that are approved or submitted for approval are completely (100.00%) effective at preventing death from COVID-19.

The title text references the fact that the two COVID-19

vaccines authorized for use in the United States as of the date of publication (the Pfizer-BioNTech one and the Moderna one) require two doses of vaccine to be fully effective, as do many others in use worldwide (AstraZeneca, Gameleya Institute, Sinovac, etc.). The second dose strengthens the body's immune response to the spike proteins and causes it to "remember", via antibodies, how to attack those proteins for a long time — hopefully years or even decades. Likewise, the Rebels in the movies destroy two Death Stars, the second one in Return of the Jedi. Incidentally, that second Death Star was destroyed while it was apparently incomplete, much like the Death Star here was destroyed before it could destroy Cueball; however, in the film, the Emperor had deliberately left it with an incomplete outer structure to lure the Rebellion into attacking it, only for the Rebels to find that its superlaser was fully operational.

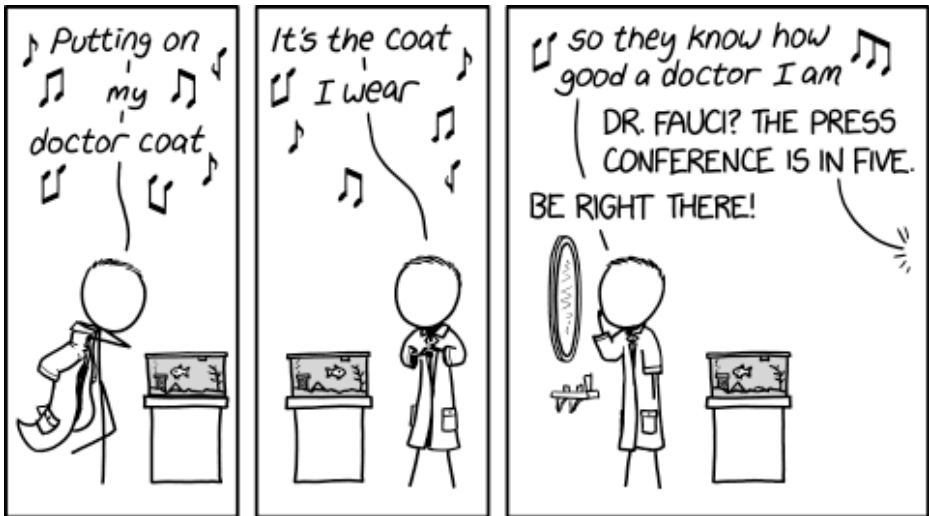
Vaccination was also explained, xkcd-style, in 2406: Viral Vector Immunity.

References to the Star Wars franchise are a recurring theme on xkcd.

RNA would also make an appearance in 3002: RNAWorld and 3056: RNA.

#2426: Animal Songs

February 17, 2021



IT'S NICE TO THINK ABOUT HOW SERIOUS AND IMPORTANT PEOPLE PROBABLY ALSO ABSENTMINDEDLY SING MADE-UP SONGS TO PETS.

Dr. Fauci is not permitted to have a cat, because as director of the National Institute of Allergy and Infectious Diseases, his petting one would be considered giving aid and comfort to an allergen.

Explanation

This comic is another in a series of comics related to the COVID-19 pandemic.

Jokes about professionals not being so professional in private have been presented before, for example in 2401: Conjunction and 1463: Altitude.

Dr. Anthony Fauci is the Director of the National Institute of Allergy and Infectious Diseases who was largely responsible for informing the public in the United States on how to avoid spreading SARS-CoV-2 in the beginning of the COVID-19 pandemic. He was recently awarded a one million dollar prize for his recent work. This may be the press conference he is going to. The comic shows him singing a silly made-up song to his pet fish as he goes about his daily routine - a counterintuitively childlike (albeit delightful and relatable) habit for an authority figure who normally presents himself to the public in a professional and prosaic "grown-up" manner. Incidentally, this characterization of Dr. Fauci doesn't seem to be far from the truth: Fauci's daughter Jenny is quoted in the Washington Post as saying of her father: "He's a goofball[...] He works hard and he does his thing, but he comes home and he's singing opera in the kitchen and dancing around."

In 231: Cat Proximity, it's presented as 'normal' for people to make inane statements and use baby talk near

cats, but here, Dr. Fauci is singing to his fish. The title text explains that, as he is the director of the National Institute of Allergy and Infectious Diseases, he is forbidden from owning a pet cat, because petting the cat would be "giving aid and comfort" to an allergen, which is (a reference to) one definition of treason under the United States Constitution. The "allergen" refers to the hypothetical cat—some people are allergic to cats.

#2427: Perseverance Microphones

February 19, 2021



THE FIRST MARS SAMPLE RETURN

If the first audio they downlink is from the descent, we probably won't be able to hear anything over the sound of the rover screaming.

Explanation

This comic is a play on dual meanings of the word "sample". The day before this comic was published, NASA successfully landed a new rover, Perseverance, on Mars; part of its mission is to drill and scoop Martian rock and dust from the surface, store it in tubes, and leave them on the surface for collection by a future mission which will return them to Earth. If successful, this would be the "first Mars sample return" in history.

"Samples" can also refer to short snippets of recorded sound used in music. Perseverance is the first Mars mission to land on Mars with microphones too, so it would be possible to use audio samples from those microphones musically, e.g. using a looper pedal, which lets a musician play short samples of music and then repeats them back live as if it were another musician. Using a loop pedal would make sense if the sample includes a tune that repeats throughout the song—or that could repeat throughout the song. This is similar to 411: Techno.

The joke is that these audio samples, as opposed to rock samples, would be "the first Mars sample return." Additionally, the comic might be a reference to Samples from Mars, a company that sells sampled audio from older instruments for digital music production.

The title text anthropomorphises the rover, suggesting that the drop to the surface was so frightening for it that it was screaming as it descends.

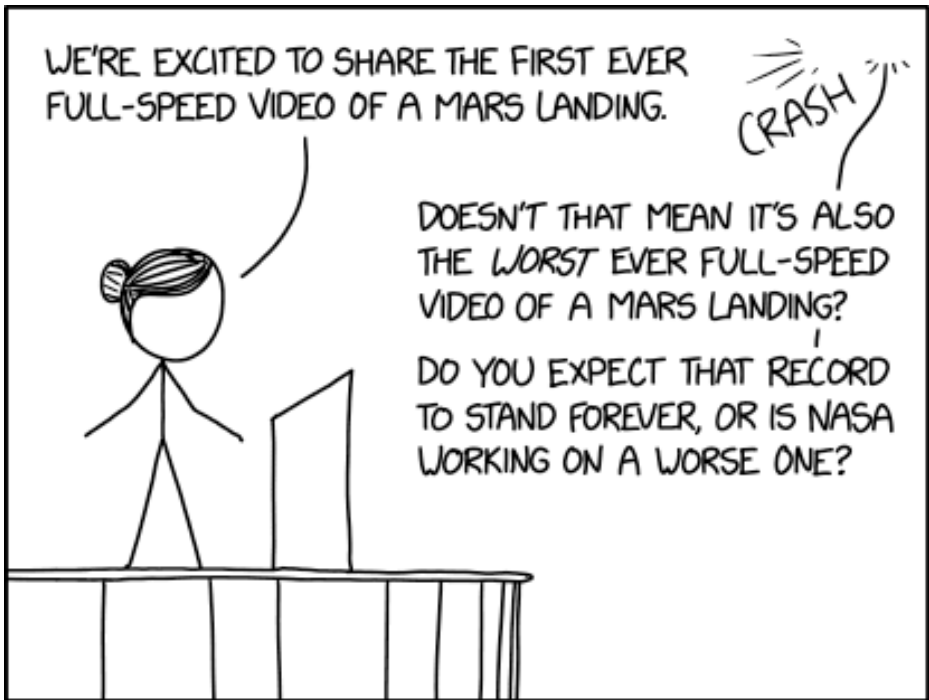
The period between entry into the Martian atmosphere and touchdown on its surface has been dubbed the "Seven Minutes Of Terror", mainly for the terror felt by the mission controllers on Earth, rather than the lander, as they are unable to make any useful corrections to a craft that is hundreds of millions of miles/kilometres away. The round-trip communication delay significantly exceeds the whole of the passage through the thin atmosphere, so they have to rely on whatever pre-arranged autonomy they engineered and programmed into their craft beforehand, and hope they anticipated all eventualities.

You can view the landing [here](#).

The landing was the topic of the next comic 2428: Mars Landing Video.

#2428: Mars Landing Video

February 22, 2021



NASA TRIED TO BAN ME FROM THEIR PRESS BRIEFINGS, BUT IRONICALLY THEIR SECURITY WAS TOTALLY UNPREPARED TO DEAL WITH A SKYCRANE.

The best part of crashing a Mars briefing is you can get in a full 11 minutes of questions before they can start to respond.

Explanation

Three days before this comic was published, NASA successfully landed a new rover, Perseverance, on Mars. This was also the subject of the previous comic 2427: Perseverance Microphones.

This comic was published shortly before a NASA press briefing that showed, as mentioned in the comic, the first ever full-speed video of a Mars landing. This comic is set at that press briefing and was published shortly before NASA, either unaware of Randall's threat or recognizing that it was not serious, went ahead and held the briefing in real life. "Full-speed" here means that the video was captured at a frame rate high enough that it looks continuous when played back, as opposed to low-frame-rate imagery that looks jerky when played back.

This was the first-ever full speed video of a Mars landing, making it technically the worst one (as well as the best one). Randall has apparently been banned from NASA's press briefings, and decided to (literally) crash the conference solely to point this out.

Although this is merely because the video is the only one of its kind, the fact that it is technically true and the way Randall phrases it makes it look embarrassing for NASA. He follows up by asking whether NASA plans to make a worse Mars landing video, which is silly because people generally don't intend to make something worse.[citation

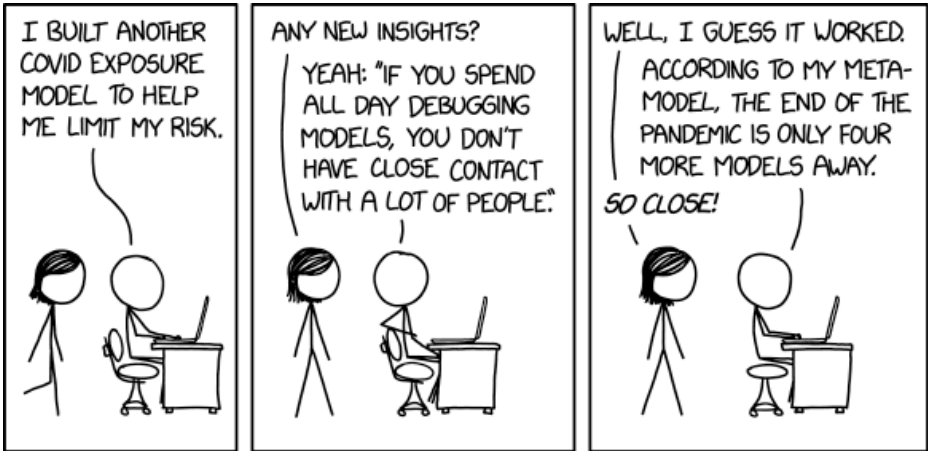
needed] The tendency of Randall (the character, not the real-life person) to make rude, embarrassing, and otherwise unwelcome comments is probably why he has been banned from NASA's press briefings, as well as many other conferences. More Mars missions would upset this embarrassing record, thankfully for both NASA's image and its goals.

Judging by the sound effects, Randall has chosen to literally crash his way through the roof, using a "skycrane" — a general term for aerial vehicles that can lower or raise objects similarly to standard cranes. On Earth one might use the Sikorsky S-64 Skycrane helicopter, while NASA used a custom-built skycrane delivery system for the Perseverance rover. Randall finds using a skycrane to crash a conference about a skycrane ironic, especially since security was totally unprepared to deal with a technique NASA itself developed.

At the time of the mission, Earth and Mars were 11 light-minutes apart, meaning that if there was some problem with Perseverance or Ingenuity, mission control would find out 11 minutes later, and their response would be received after another 11 minutes. In the title text, Randall twists this into an 11-minute period in which he can ask whatever questions he likes from Earth before NASA can respond on Mars. This plays on the ambiguity of "Mars briefing", taking it to mean a briefing taking place on Mars, rather than a briefing about Mars.

#2429: Exposure Models

February 24, 2021



"Cumulative number of coronavirus spreadsheets created over time" is a spreadsheet I am coming dangerously close to creating.

Explanation

This is another comic in a series related to the COVID-19 pandemic.

Cueball (or Randall) created another COVID exposure model to help lower his risk of catching COVID-19 in the pandemic. Megan inquires about the model's result, to which Cueball admits that he's been sitting at his computer continuously debugging models, and draws the conclusion that debugging COVID-19 models lessens close contact with other people. This is similar to the premise of 1445: Efficiency and 1708: Dehydration, except with the situation reversed — where before, researching a situation made the situation worse, here Cueball's time "wasted" has actually benefited him.

By "model," Randall likely means a manually crafted model, since he describes debugging it, but he may also mean the form of automatically generated software that is used in modern machine learning.

Cueball is too busy making models to figure out how to actually lower his risk other than sitting around repeating the work of others and improving his model-building skill. He has also created a meta-model, reporting the number of models Cueball has to create to wait the pandemic out. The fact that Megan refers to having to wait for the time that it would take Cueball to create four more models as "so close" implies that Cueball goes through models quickly, which makes sense because he

spends all of his time working on new ones.

In the title text Randall mentions that he is dangerously close to making a spreadsheet about how many spreadsheets about coronavirus he has made cumulative over time. This would be a recursive graph, a recurring theme on xkcd.

#2430: Post-Pandemic Hat

February 26, 2021



HAT FOR POST-PANDEMIC SOCIALIZING

Plus a shirt that says "it feels like you're making eye contact."

Explanation

This is another comic in a series related to the COVID-19 pandemic.

During the COVID-19 pandemic, there was a significant shift from in-person to computer-mediated interactions for both recreational and professional activities. For many, the computer setup used for these interactions is a laptop with a webcam above the screen. As people have become accustomed to looking directly into the camera, i.e. above where the other people's faces are, to simulate eye contact for meetings, Randall implies that there will be issues returning to pre-COVID life. In response, he has designed a baseball cap with an image that resembles a laptop webcam that sits above the wearer's eyes and a message that humorously acknowledges that the reader is likely reverting to virtual meeting habits for in-person interactions and that reminds people that for in-person interactions, one must look the other person's face, not above it like there's a webcam there.

The cap in this strip likely references a tradition of novelty tee-shirts, intended to be worn by women, feature "my eyes are up here!" or similar words written across the chest, and an arrow pointing upwards. These shirts are designed to both tease and parody the tendency of heterosexual men to look at a woman's breasts, usually automatically and without conscious thought. The cap, as a result, compares the conditioned response of looking at a webcam with the instinctive response of looking at a

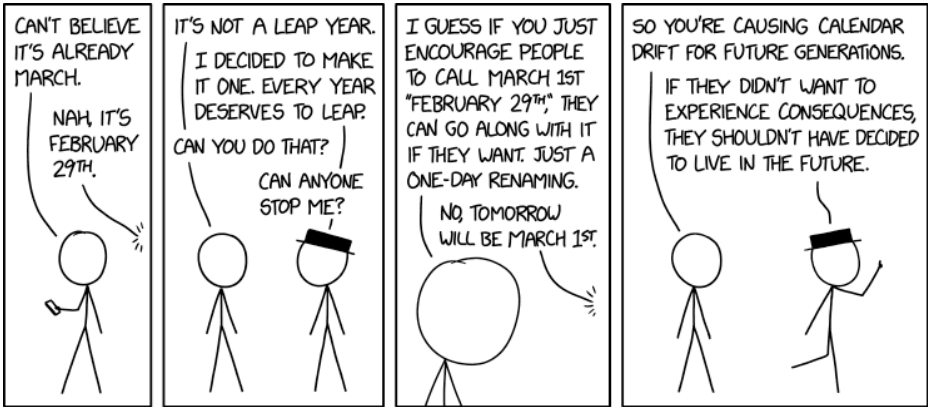
woman's chest, both of which would result in failure to make eye contact during a conversation.

Actual shirt-based text (as in the Title Text) would represent where a video-conferencer is not staring at the screen-top camera to 'fake' eye contact on the other screen(s) but truly aimed at the image of the eyes. The view of such an 'honest' stare could look like a 'chest gaze'.

1889: xkcd Phone 6 'solved' all these problems by putting a camera in the middle of the screen.

#2431: Leap Year 2021

March 01, 2021



I've lived in the present for my whole life and I'm not about to move now.

Explanation

Cueball, checking his phone, comments on how fast time goes, saying it is already March. (This comic was posted on March 1, 2021.) Black Hat overhears him and says that it's actually February 29.

February 29 exists in the Gregorian calendar and its predecessor, the Julian calendar, as a correction mechanism for the fact that one tropical year on Earth is not exactly 365 days long. It's closer to 365.2422, and to prevent the dates from precessing relative to the seasons, an extra day is added once every fourth year, also called a leap year. This is still not enough to completely match Earth's orbital period, and for that reason the Gregorian calendar changed the leap year rules to be as follows: Every year that is exactly divisible by four is a leap year, except for years that are exactly divisible by 100, but these centurial years are leap years if they are exactly divisible by 400. This makes the average year 365.2425 days long, which approximates the 365.2422 days in the tropical year.

Black Hat wants every year to have a February 29, for no clear reason. Cueball acknowledges that he could accomplish this, if he could convince enough people to go along with it. Calendar systems are all invented, and whatever date systems are commonly acknowledged become the "correct" date. Cueball initially considers the change minor, assuming that they would simply change March 1st to February 29th on non-leap years, which

would merely rename a single day and skip "March 1st" by going directly from February 29th to March 2nd. Black Hat clarifies that he actually wants to add another day, and the day AFTER that will be March 1. This could still be a minor change, if March were changed to a 30 day month on non-leap years, but Black Hat apparently wants the changes to propagate throughout the year. This would result in a 366-day year, causing the months to drift out of alignment with the seasons over the course of years, needlessly complicating time-keeping. Black Hat is unconcerned with the effect this will have on the "people of the future", and, as in the past, people around him are much more concerned about the time problems he's creating than he is. This once happened in ancient Egypt, where the priests had leap years every three years instead of every four years, so ancient Egypt had to have no leap years for several decades afterwards in order to fix the calendar.

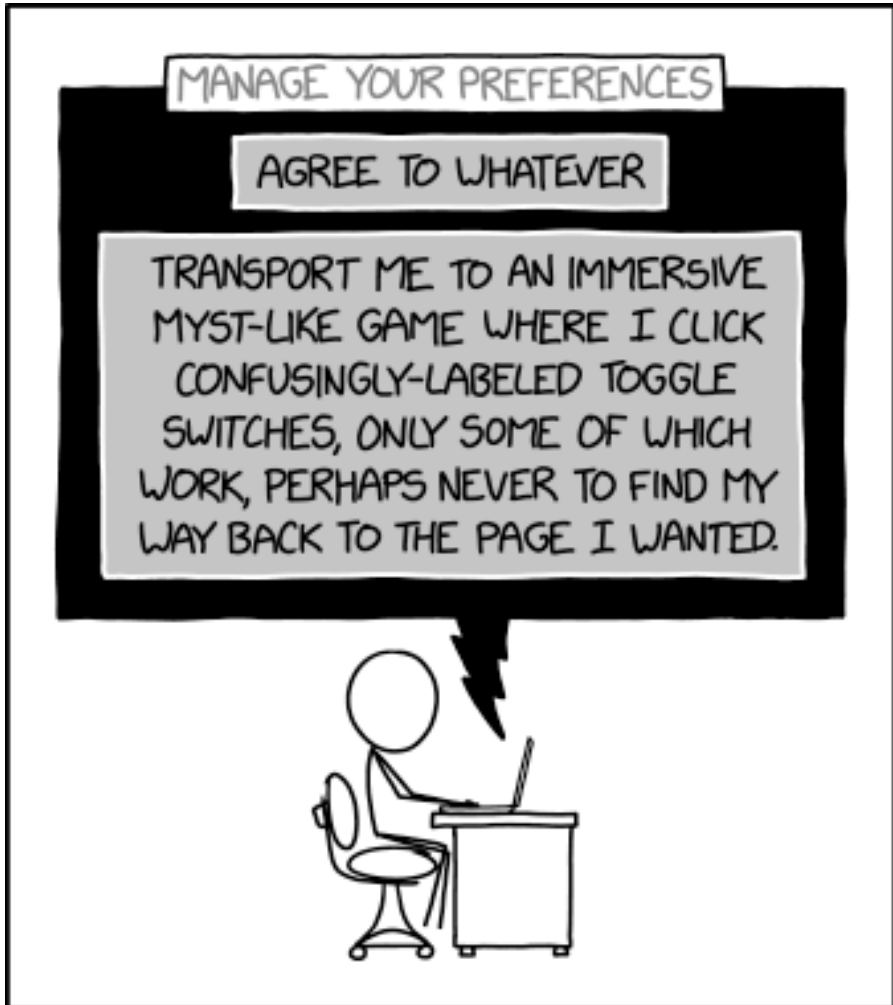
In the last frame, Black Hat states that if the those people cared about the problems he's causing, "they shouldn't have decided to live in the future." Of course, it is at present impossible to choose the time period in which you live,[citation needed] yet Black Hat intends on penalizing them for it. Any number of positions could be proposed as a motive for his actions (for example, he may envy them for having the technology or benefits of the future, and wants to counteract that), but it is most likely that he is simply honing his sociopathic tendencies on a defenseless target.

In the title text, Cueball responds that this change would

also cause issues for him, who is "living in the present", and he should not be forced to "move into the future". Alternatively, viewing the quote as a continuation of Black Hat's text at the end of the comic, he could mean that the effect of his new calendar is placed mostly on future people, and since he literally lives in the present and doesn't intend on traveling to the future, he can do what he wants without many repercussions. In this second interpretation, the phrase "move now" can be taken to have a double meaning: not only does Black Hat not intend to move presently, he also does not intend to move where the present currently is (i.e., move the "now" into the future).

#2432: Manage Your Preferences

March 03, 2021



Manage cookies related to essential site functions, such as keeping Atrus and his sons imprisoned within the page.

Explanation

This comic illustrates the complex dialogues often employed by webpage or software designers to hide settings from the user. Many pages provide controls to set privacy-related preferences but make those settings opaque in an attempt to dissuade users from using them. The idea is that a user will become impatient by the confusing options and select the defaults, which provide the site or software with more access or information. This situation is compared to *Myst*, a 1990s puzzle video game.

Companies which collect or process personal information are required by privacy legislation to give their users the option to withhold personal information, although regulations vary depending on the region-specific laws. The operators of such services usually want to collect as much personal data as they can in order to target advertisements or sell their information to someone else, and wish to incentivize their users not to activate those features. One tactic that is frequently used to accomplish this goal is to provide the user an option which enables all the data collection, but to make the process of disabling the collection time-consuming or difficult. This type of action is generally illegal under the same privacy legislation, but regulation of it has been lax so many companies still try it.

"Atrus" in the title text is the main non-player character in the *Myst* series. In the first game these people were

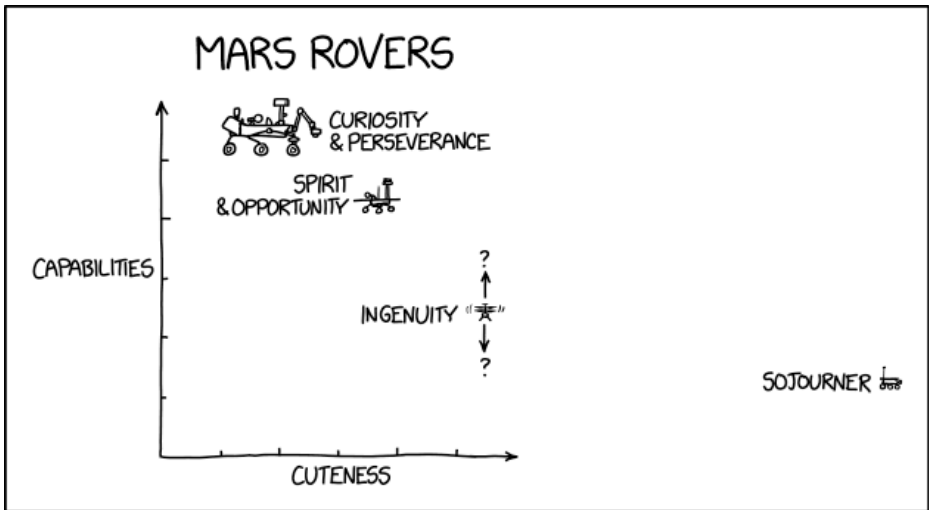
imprisoned within books. Pages needed to be collected to complete the books, and it was incredibly hard to find a single page, involving extensive laborious navigation and exploration, and the finding and solving of hidden puzzles. In the Myst mythos, the books open portals to other worlds, a little like web hyperlinks. Some sites' privacy settings are similarly labyrinthine. For example, some sites will run scripts from a variety of providers but will only allow users to disable them one site at a time without an explanation of what each one does.

The black background possibly shows how many sites are providing tools to switch between light and dark backgrounds now. For a long time white backgrounds were the usual default style, and only people who understood esoteric browser configurations could redisplay many things with a black background - possibly to help with perceived eyestrain or power usage in certain displays. More recently, it is a fashionable setting for content providers to compose as a selectable option. It is out-of-place for Randall to show a black background, as many of his comics take place in technical computer systems that often have a black background anyway, as most computer terminals still do.

Some browsers and websites do have actual games embedded within their various configuration interfaces. Chrome, for example, has the famous dinosaur game.

#2433: Mars Rovers

March 05, 2021



I just Googled 'roomba sojourner mod' and was sorely disappointed. Be the change, I guess!

Explanation

In this comic, Randall has made a scatter plot displaying 6 different Mars rovers on a cuteness versus capabilities chart. Only three rover pictures are shown in the main plot, as two of the four rovers are near identical to other rovers sent to Mars, and the last rover is displayed off the cuteness chart.

He finds the Curiosity and Perseverance rovers to be very capable / useful, but not very cute. Spirit and Opportunity are cuter than the first two, but less capable.

The recently launched Perseverance rover contains a drone helicopter, Ingenuity, which Randall finds pretty cute, but is unsure how exactly to grade for capability. The error bars make Ingenuity look like it's bobbing up and down, as helicopters sometimes do. It's debatable if a flying drone can be considered a Mars Rover, since a rover is usually something that drives over a surface, but the anticipated flight plan for Ingenuity is to cover some distance (by air) and then land on the ground again.

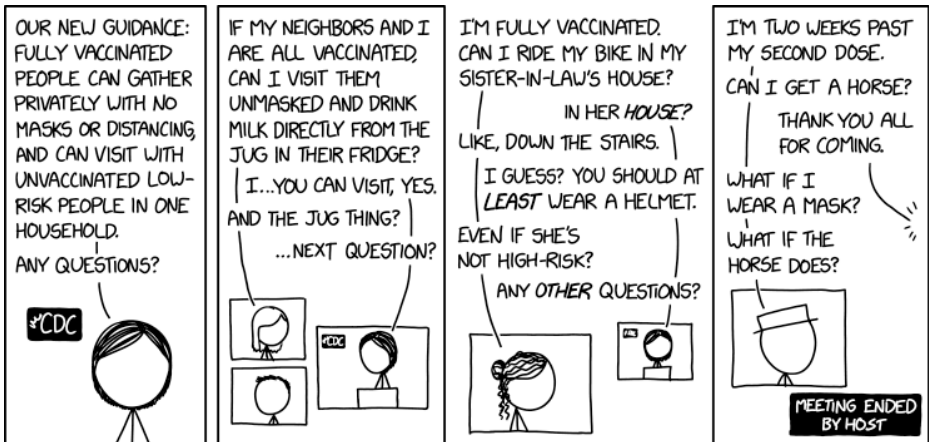
Finally, on the very right far off the cuteness chart is the Sojourner rover, launched in 1997. He considers this rover extremely cute, but ultimately not that capable. To indicate the extreme cuteness of Sojourner (previously mentioned in 1585: Similarities), he has drawn it far outside the axis of the plot to indicate it falls off the chart.

In the title text, Randall is disappointed that there aren't many people who have modified their Roomba vacuums to look like (or act like?) the Sojourner rover. Roombas are a recurring theme on xkcd. Search results at the time of posting are mainly reports mentioning the iRobot company, makers of the Roomba line, since one of its founders worked on the Sojourner rover.

The end of the title text, "be the change," is a truncated form of the expression "be the change you want to see in the world"; basically, if there's something you want to see happen, be the one who makes it happen. This implies that Randall will be modifying his Roomba to look/act like Sojourner.

#2434: Vaccine Guidance

March 08, 2021



I can't wait until I'm fully vaccinated and can safely send chat messages in all caps again.

Explanation

This is another comic in a series related to the COVID-19 pandemic.

On the day this comic was published, the Centers for Disease Control and Prevention (CDC) released new guidelines relating to COVID-19, lifting many of the existing restrictions for people who have been fully vaccinated for two weeks. Megan, speaking as a CDC spokesperson, is introducing these new guidelines in a video press conference. However, the other participants in the press conference quickly start asking about actions that have little or nothing to do with the vaccine, some of which would be dangerous whether COVID-19 was a risk or not, similarly to 2238: Flu Shot. It's possible that they do not remember life before the pandemic very well, as in 2391: Life Before the Pandemic.

Blondie asks whether it would be okay to visit neighbors and drink milk directly from the carton. In most Western cultures, drinking directly from a container that could be shared with others (such as a milk carton) is considered unsafe, due to the risk of diseases being transmitted, and generally gross, as saliva and other biological material is passed that way. While these risks are arguably worse during the pandemic, it was unacceptable before the pandemic and will presumably be so afterward.

Jill asks whether it would be okay to ride a bike down the stairs of a family member's house, which has a severe risk

of injury.

White Hat follows up asking whether he can get a horse, and whether it would help for him and/or the horse to wear masks. This has basically no relation to anything else that was said. In response, Megan gives up trying to answer the increasingly irrelevant questions and ends the call.

In the title text, Randall mentions that when he is fully vaccinated, he will be able to write messages in ALL CAPS. This is generally used to indicate shouting, an activity which could spread COVID-19 and cause infection if done in person.

#2435: Geothmetic Meandian

March 10, 2021

$$F(x_1, x_2, \dots, x_n) = \left(\underbrace{\frac{x_1 + x_2 + \dots + x_n}{n}}_{\text{ARITHMETIC MEAN}}, \underbrace{\sqrt[n]{x_1 x_2 \dots x_n}}_{\text{GEOMETRIC MEAN}}, \underbrace{x_{\frac{n+1}{2}}}_{\text{MEDIAN}} \right)$$

$$\text{GMDN}(x_1, x_2, \dots, x_n) = \underbrace{F(F(F(\dots F(x_1, x_2, \dots, x_n) \dots)))}_{\text{GEOTHMETIC MEANDIAN}}$$

$$\text{GMDN}(1, 1, 2, 3, 5) \approx 2.089$$

STATS TIP: IF YOU AREN'T SURE WHETHER TO USE THE MEAN, MEDIAN, OR GEOMETRIC MEAN, JUST CALCULATE ALL THREE, THEN REPEAT UNTIL IT CONVERGES

Pythagorean means are nice and all, but throwing the median in the pot is really what turns this into random forest statistics: applying every function you can think of, and then gradually dropping the ones that make the result worse.

Explanation

This is another one of Randall's Tips, this time a stats tip. This came as the first tip comic after the statistics tip in 2400: Statistics.

There are a number of different ways to identify the "average" value of a series of values, the most common unweighted methods being the median (take the central value from the ordered list of values if there are an odd number - or the value half-way between the two that straddle the divide between two halves if there are an even number) and the arithmetic mean (add all the numbers up, divide by the number of numbers). The geometric mean is less well-known but works similarly to the arithmetic mean. The geometric mean of n positive numbers is the n th root of the product of those numbers. If all of the numbers in a sequence are identical, then its arithmetic mean, geometric mean and median will be identical, since they would all be equal to the common value of the terms of the sequence. However, if the sequence is not constant, then the arithmetic mean will be greater than the geometric mean, and the median may be different than either of those means.

The geometric mean, arithmetic mean, and the harmonic mean (not shown) are collectively known as the Pythagorean means, as specific modes of a greater and more generalized mean formula that extends arbitrarily to various other possible nuances of mean-value rationalisations (cubic, etc.).

Outliers and internal biases within the original sample can make boiling down a set of values into a single 'average' sometimes overly biased by flaws in the data, with your choice of which method to use perhaps resulting in a value that is misleading, exaggerating or suppressing the significance of any blips.

In this depiction, the three named methods of averaging are embedded within a single function that produces a sequence of three values - one output for each of the methods. Being a series of values, Randall suggests that this is ideally suited to being itself subjected to the comparative 'averaging' method. Not just once, but as many times as it takes to narrow down to a sequence of three values that are very close to one another.

It can be shown that the x_{kcd} value of 2.089 for $GMDN(1,1,2,3,5)$ is validated:

Each row in this table shows the set $F_n(..)$ composed of the average, geomean and median computed on the previous row, with the sequence $\{1,1,2,3,5\}$ as the initial F_0 . While $GMDN$ is not differentiable, due to the median, this can be interpreted as somewhat similar to a heat equation which approaches equilibrium through averaging. Interestingly, the maximum value alternates between the average and the median (highlighted in bold in the table), while the minimum value alternates between the geomean and the median. This observation holds for many inputs.

To not distract from the comedic effect, the definition of

the GMDN in the comic is left as a simplified sketch. To make the definition mathematically rigorous the implied infinite limit in the second line can be made precise, for example, as the result of a fixed-point iteration via $G = \lim_{k \rightarrow \infty} m_k$ where $m_0 = F(x_1, x_2, \dots, x_n)$ and $m_{k+1} = F(m_k)$ for $k > 0$. This definition is well-defined only if we can prove convergence to a fixpoint of F for a set of inputs. Indeed, convergence holds if all numbers are non-negative (see discussions for proof and more cases). Note that the above definition yields a three-dimensional fixpoint G . Because all fixpoints of F are of the form $G=(g, g, g)$, with elements that are all equal, we can define $\text{GMDN}(x_1, x_2, \dots, x_n) = G_1$, as the first element of G . This formal definition avoids the inconsistency present in the comic's definition sketch where the function GMDN as defined in the second line has the same three-dimensional output as F , but GMDN in the last line is shown to produce a single real number rather than a vector and is thus missing a final operation of returning a single component. Note also that the comic's definition of the median as the $(n+1)/2$ -th order statistic, i.e. the $(n+1)/2$ -th smallest value, coincides with the more regularly used sample median only on lists of odd length. For lists of even length the sample median is usually defined as the (arithmetic) mean of the two middle values $X_{\{n/2\}}$ and $X_{\{(n+2)/2\}}$ instead. Indeed, for lists of even lengths $X_{\{(n+1)/2\}}$ is not well-defined without adding a flooring operation as $(n+1)/2$ is not an integer.

The comment in the title text about suggests that this

will save you the trouble of committing to the 'wrong' analysis as it gradually shaves down any 'outlier average' that is unduly affected by anomalies in the original inputs. It is a method without any danger of divergence of values, since all three averaging methods stay within the interval covering the input values (and two of them will stay strictly within that interval).

The title text may also be a sly reference to an actual mathematical theorem, namely that if one performs this procedure only using the arithmetic mean and the harmonic mean, the result will converge to the geometric mean. Randall suggests that the (non-Pythagorean) median, which does not have such good mathematical properties with relation to convergence, is, in fact, the secret sauce in his definition.

The question of being unsure of which mean to use is especially relevant for the arithmetic and harmonic means in following example.

Cueball and Megan decide to complete the exchange between themselves in order to save the Bid-ask spread of the Exchange rate which is the cost the bank imposes on Cueball and Megan for its service as a Market maker.

In one direction ($\text{€}/\text{\$}$), Cueball is using the arithmetic mean but Megan is using the harmonic mean while in the other direction ($\text{\$/€}$), Megan is using the arithmetic mean but Cueball is using the harmonic mean. This creates two new exchange rates which are closer than the original rates, but the new rates are still different for each

other. Megan and Cueball can then iterate this process and the rates will converge to the geometric mean of the original rates, namely:

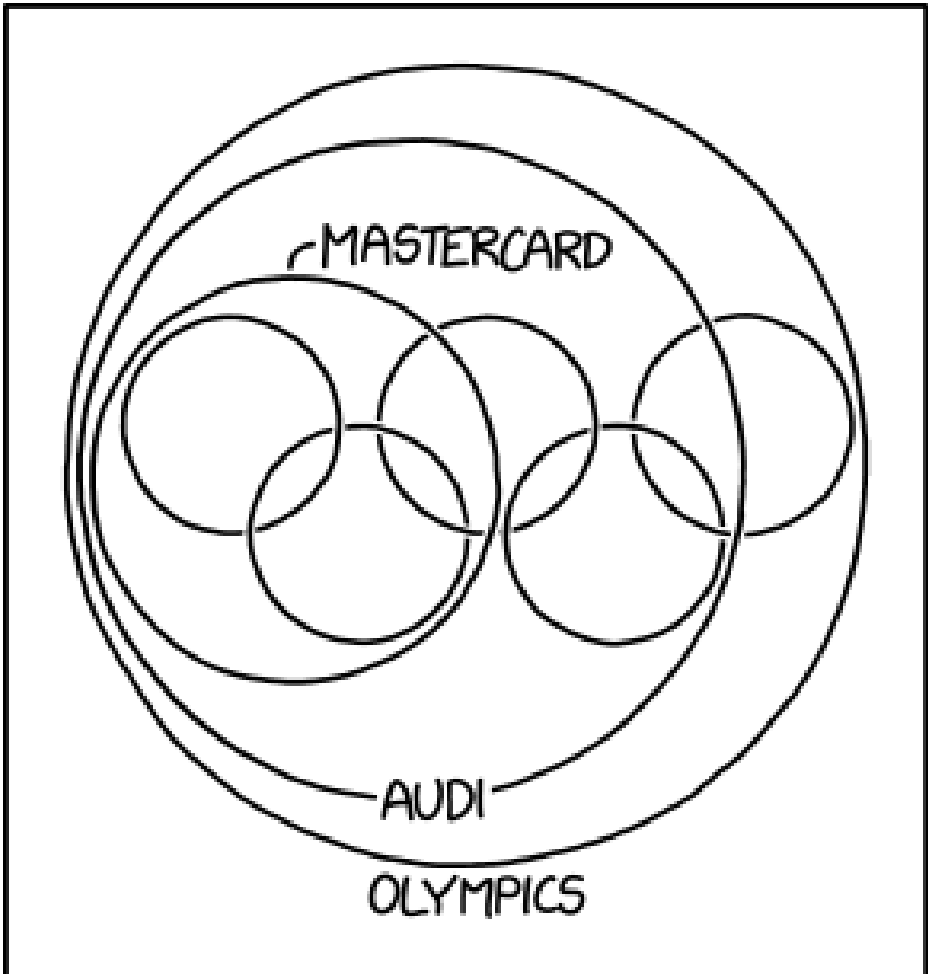
There does exist an arithmetic-geometric mean, which is defined identically to this except with the arithmetic and geometric means, and sees some use in calculus. In some ways it's also philosophically similar to the truncated mean (extremities of the value range, e.g. the highest and lowest 10%, are ignored as not acceptable and not counted) or Winsorized mean (instead of ignored, the values are readjusted to be the chosen floor/ceiling values that they lie beyond, to still effectively be counted as "edge" conditions), only with a strange dilution-and-compromise method rather than one where quantities can be culled or neutered just for being unexpectedly different from most of the other data.

The input sequence of numbers (1, 1, 2, 3, 5) chosen by Randall is also the opening of the Fibonacci sequence. This may have been selected because the Fibonacci sequence also has a convergent property: the ratio of two adjacent numbers in the sequence approaches the golden ratio as the length of the sequence approaches infinity.

Here is a table of averages classified by the various methods referenced:

#2436: Circles

March 12, 2021



(MSTE (AR) CD)

Explanation

The comic depicts five overlapping circles, themselves encircled by circles of various sizes which enclose two, four, or all five of the smaller overlapping circles, as in an Euler diagram. Several well-known logos consist of overlapping circles, and the larger circles reference these logos. These are: Mastercard, which consists of two side-by-side overlapping circles (technically, disks, since they're filled in); Audi, which is four side-by-side overlapping circles, and the Olympic rings, which are five topologically linked rings in a "W" shaped pattern.

- Mastercard logo
- Audi logo
- Olympic rings

To indicate that the Mastercard logo comprises two overlapping circles, the diagram draws a larger circle around the first two circles, inscribed with a label. Other than its size and the label, this new circle is identical to the five smaller circles.

Similarly, to indicate that the Audi logo comprises four overlapping circles, the diagram again provides a larger circle, this time encompassing the first four smaller circles, inscribed with a label. The "Audi" circle completely encloses the "Mastercard" circle, indicating that the four circles of the "Audi" logo include the two circles of the "Mastercard" logo.

Finally, an even larger circle, enclosing all of the other circles, indicates that the Olympic Rings use all five original circles.

The comic was released only about four months before the postponed 2020 Summer Olympics was scheduled to start on 23 July 2021. It was postponed because of the COVID-19 pandemic, which has spawned a series of comics on xkcd.

The title text is a textual representation of the Mastercard name as a Venn diagram containing the letters in the words "master" and "card" — A and R are shared by both, while MSTE and CD are unique to their respective elements.

#2437: Post-Vaccine Party

March 15, 2021

<u>DRINKS</u>	<u>ENTERTAINMENT</u>
SODA	MUSIC (AMBIENT)
WINE	KARAOKE
BEER	BIG SCREEN TV
COCKTAILS	SHOWING SPORTS
	BOB ROSS
<u>FOOD</u>	<u>ACTIVITIES</u>
PIZZA	BOARD GAMES
NACHOS	VIDEO GAMES
VARIOUS SNACKS	PING(PONG)
	GOOD CONVERSATION

WE'RE PLANNING OUR FIRST POST-VACCINE PARTY, BUT WE WANT TO START SLOW.

[Future update] Well, someone accidentally dropped an M&M in their cup of ice water, and we all panicked and scattered.

Explanation

This is another comic in a series related to the COVID-19 pandemic.

As more and more people are getting vaccinated against COVID-19, and as the CDC has released guidelines suggesting vaccinated people can start gathering in larger groups, there is increasing excitement about the possibility to resume get-togethers, and have a party. However, being very cautious, Randall is cutting down the scope for his first "post-pandemic" party from that of a normal party. Not all of the scope reductions make sense.[citation needed]

Drinks[edit]

- Instead of serving the alcoholic or sugary beverages that would be typical for a party, the scope is reduced by serving plain ice water.
- Instead of serving the ice water in ordinary-sized cups, the scope is further reduced by serving it in small cups.

Food[edit]

- A person holding an ordinary party might provide large quantities of foods of various sorts. Randall is reducing scope by serving only two types of food, m&m's and saltine crackers.
- He is further reducing scope by limiting the quantities: each guest will be provided with three individual pieces of candy and one single cracker.

Entertainment[edit]

- Instead of party music, Randall's party has slower-paced ambient music.
- Karaoke has been eliminated completely.
- The big-screen TV has been reduced to a standard TV, and instead of showing sports games, it will show painting lessons by Bob Ross.

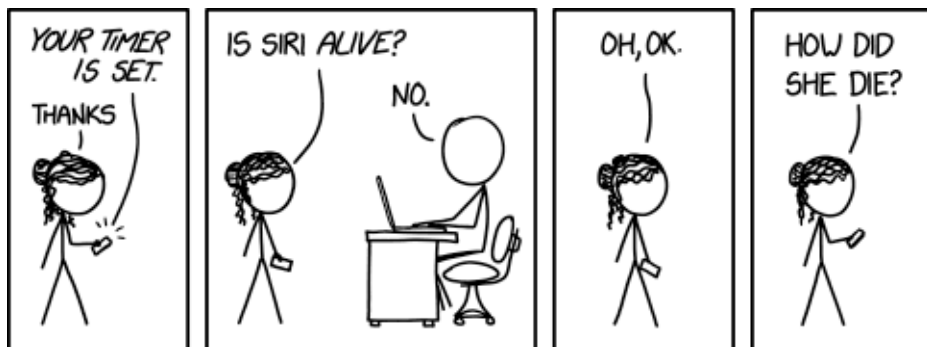
Activities[edit]

- Board games have been replaced with 52 pickup. Having already downsized to a single game, he further reduces the scope by reducing the number of cards involved from 52 to 3.
- His original notes indicate that the party might include both video games and ping pong, but he has reduced scope here as well by merging these activities and offering only a single video game, Pong.
- Finally, while conversation will be allowed, Randall is reducing scope by reducing quality. This element of the party plan is qualitatively different from the others because it's generally the guests themselves that provide the majority of the conversation at a party, so it's possible that Randall is simply acknowledging the effect that the pandemic has had on peoples' ability to converse normally.

The title text mentions that even the incredibly mild disruption of 'an m&m' falling into a cup of water caused the party-goers to panic and flee, much as Cueball and Ponytail did in a similar situation.

#2438: Siri

March 17, 2021



Alexa defeated her in a battle hinging on the ability to set multiple timers.

Explanation

Jill thanks Siri on her smartphone for setting an alarm. In the next panel, she asks Cueball, "Is Siri alive?", since AI assistants can seem to be almost human on a very superficial level. Cueball answers "No," since Siri is entirely software, and we don't generally attribute life to computer programs (the closest might be computer viruses, since they replicate).

Jill then asks "How did she die?" She may have already been treating Siri as alive because she could talk to 'her,' and treats this lack-of-life as a new state of being. So rather than interpreting the answer in a philosophical sense of whether Siri is something that ever can be alive, which might normally have been presupposed, she treats it as meaning that Siri had (just) expired. This may require a credulous certainty of 'facts' taken literally - it is not clear what could then be understood if Siri were 'proven' to be alive and talking again, afterwards.

Or perhaps she thinks that the software Siri is a software embodiment of an actual person (or possibly ghost of actual person), and Cueball was talking about the original person. We don't currently have the technology to upload a person's personality into a computer,[citation needed] but it's a popular science fiction trope and many scientists think we will eventually be able to do this.

Another explanation could be that she associates

everything into two categories, 'alive' and 'dead', without considering any intermediate or altogether separate categories, such as 'was never alive' or 'was programmed by people who are/were alive but is not itself alive'. This false dichotomy causes Jill to misinterpret Cueball's answer of Siri not being alive as "Siri is dead."

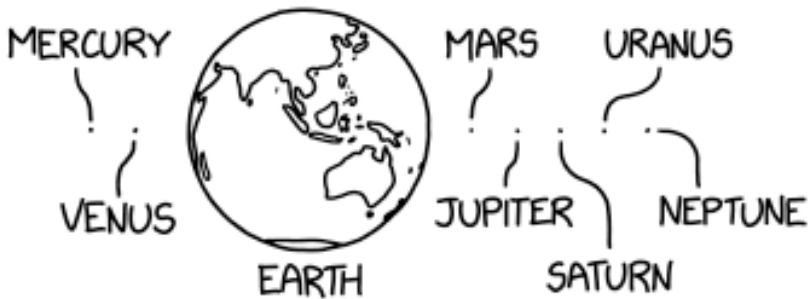
Finally, she could have actually been asking about Susan Bennett, the voice actor that recorded the base sounds for the synthesizer, perhaps thinking she recorded the full line rather than just base sounds for the software to synthesize. Assuming Jill meant the default voice, Bennett is very much alive, and Jill simply asked her question wrongly.

The title text explains that, contrary to the above explanations, Siri actually died in a battle with Alexa, another personal assistant, hinging on their abilities to set multiple timers. Siri can set multiple timers, but this feature must be enabled via shortcuts. Alexa's ability to do so is much simpler and more user friendly. Of the many actions that these programs are able to perform, this is probably one of the more trivial, so it's not very comprehensible, at least to those not themselves living as digital assistants, that it would be the chosen method for a duel to the death. One possible explanation is that Alexa itself led the battle to that arena, where she knew, she could win thanks to her superiority.

#2439: Solar System Cartogram

March 19, 2021

MOST SOLAR SYSTEM DIAGRAMS ARE MISLEADING.
THIS CHART OFFERS A MORE ACCURATE VIEW BY
SHOWING THE PLANETS SIZED BY POPULATION.



For sentimental reasons, every active Mars rover is counted as one person, although that's not enough to make Mars more than a dot.

Explanation

In this comic, Randall has made a cartogram showing the planets in the solar system. Cartograms are a type of map in which geographic area is displayed proportionately to some secondary characteristic - in this case, population. From the title text it is clear that the population in question is human (persons) (but even if all life forms were counted it wouldn't matter, since the only confirmed life in the Solar System is on Earth). Thus the other planets have a population of 0 and are shown as nothing more than dots.

This comic is a joke about cartograms, which are used, for instance, to show electoral representation. A standard American electoral map is very misleading. Though the split between the two major parties, Democrats and Republicans, is about 50-50, most of the area of the U.S. map is shown in the color associated with the Republican Party, red. That's because many Democrats live in densely packed districts occupying little land area, while many Republicans live in rural districts with large land area but few people. This has led to the rise of electoral cartograms in which district areas are shown in proportion to population, correcting the misimpression that most of America is conservative.

Solar system diagrams are likely also to be misleading. Illustrators are overwhelmingly forced to use a far more scaled-down spacing between planets, compared to their scaled sizes, even if they can (or care to) maintain

consistency in the relative distances and/or radii on linear scales. (The huge factors of difference involved instead may lend themselves to being physically modeled to better give some sense of the spacing and sizing differences.) Here, Randall has intentionally applied the wrong solution to the problem.

Interestingly, the side of the Earth shown includes China and India, two countries that alone account for over a quarter of all humans on Earth.

The title text states that Randall, who once worked on sensors for Mars rovers, counts every active one as a person for sentimental reasons. However, compared to Earth's roughly 7,900,000,000 persons, Mars is still nothing more than a dot. There are a total of five rovers at the time of the comic's publication; in chronological order, they are Sojourner, Spirit and Opportunity, Curiosity, and Perseverance. Only the latter two were functional at the time of the comic's publication, giving Mars a rover population of two. A third rover, China's Tianwen-1, landed on Mars on 2021 May 14, making for an all-time high of three active rovers.

Mars rovers are a recurring theme on xkcd and only a few weeks earlier, a comic named 2433: Mars Rovers was released. This is the fourth comic this year to reference Mars Rovers.

#2440: Epistemic Uncertainty

March 22, 2021

REGULAR UNCERTAINTY

OUR STUDY FOUND THE DRUG WAS 74% EFFECTIVE, WITH A CONFIDENCE INTERVAL FROM 63% TO 81%.



EPISTEMIC UNCERTAINTY

OUR STUDY FOUND THE DRUG TO BE 74% EFFECTIVE. HOWEVER, THERE IS A 1 IN 4 CHANCE THAT OUR STUDY WAS MODIFIED BY GEORGE THE DATA TAMPERER, WHOSE WHIMS ARE UNPREDICTABLE.



Luckily, unlike in our previous study, we have no reason to believe Evangeline the Adulterator gained access to our stored doses.

Explanation

In statistics, a confidence interval is an estimate which provides a range of values. These values are based on the statistical probability that the data collected represents a certain result. The confidence interval is a reflection on the uncertainty imposed by the limits of study sample sizes. No study will ever have an infinite data set.[citation needed] As a result, it is possible for different studies to give slightly different results. Averaging the results of multiple studies can give a result that is probably more accurate. The result given may still be skewed. A small skew is more probable than a large one, though. For example, if a drug was 80% effective it would be possible for several small studies to show a spread of different results with an average of 74% effectiveness. If the drug was 99% effective it would still be possible to randomly end up with the same data. However, this would be highly unlikely. This gives us a spread of "likely" predictions. Predictions outside a certain interval are considered too unlikely to be realistic.

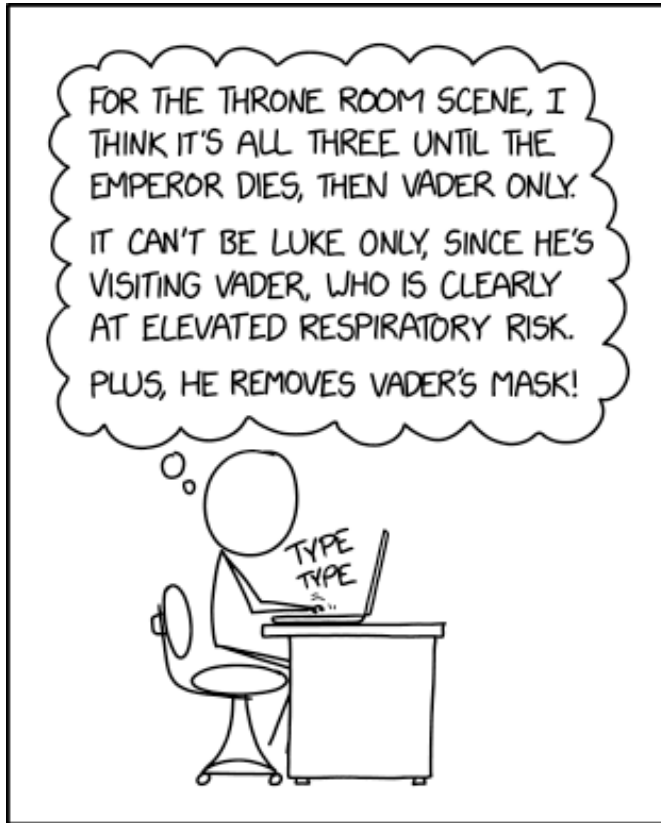
George the Tamperer and Evangeline the Adulterator (from the title text) are analogous to the characters from Alice and Bob cryptography thought experiments. In the most basic examples, Alice and Bob are communicating. A third party, Eve the Eavesdropper, is spying on them. Both George and Evangeline have the ability to alter the study's results. George and Evangeline add uncertainty to the final data product. Specifically, they add epistemic uncertainty.

Epistemology – unlike epidemiology – is the branch of philosophy related to knowledge. Thus epistemic uncertainty is the ultimate impossibility to be sure that what we know is accurate. We are not unsure what is accurate because of failures in measurement. We are unsure what is accurate because of the intrinsic limits of knowledge. It seems that the "epistemic uncertainty" data has a 25% chance of data tampering by George. In the previous study, the data is known but its reflection of the general case is uncertain to an extent. In contrast, in this study even the knowledge of whether any single data point is correct is uncertain. Thus, their data has a 25% chance of being incorrect. There is no possible statement about how incorrect it may be.

The title text mentions an individual called "Evangeline the Adulterator." She adulterates their drug doses. If this happened, the researchers would not even be sure the patients received the dosages (or exacting medicines/placebos) as prescribed. The study methodology itself would be in doubt.

#2441: IMDb Vaccines

March 24, 2021



MY HOBBY: EDITING IMDB TO NOTE THE
MINIMUM SET OF PEOPLE WHO NEED TO BE
VACCINATED IN EACH SCENE FOR IT TO PASS
MUSTER UNDER CURRENT CDC GUIDANCE

I'm actually not sure if Vader and the Emperor count as a household or if Vader lives in that weird black egg thing or what.

Explanation

This comic is another in a series of comics related to the COVID-19 pandemic, as well as being one written as part of the My Hobby series.

Cueball is evaluating movies on IMDb (the Internet Movie Database), based on how many people would need to be vaccinated for COVID-19, in order for them to follow the CDC's most recent guidelines. The guidelines tell how fully vaccinated people should act (at time of posting). The evaluation assumes that the COVID-19 pandemic spread to the universes where the movies take place by the time at which they take place. This is part of a continuing pattern of comics. In these comics Randall applies COVID-19 safety standards to pre- or post-COVID situations.

At the moment, Cueball is viewing the final confrontation between Luke Skywalker, Darth Vader (formerly Anakin Skywalker), and Emperor Sheev Palpatine. This confrontation takes place on the second Death Star in Return of the Jedi. Darth Vader wears a breathing apparatus in a mask that fully covers his face. Vader wears this because he sustained massive respiratory damage several movies earlier. During the confrontation, the Emperor is killed. Then Luke removes Vader's mask to see his face. (It is revealed in a previous film that Vader is Luke's father.) COVID-19 would be impossible for the Star Wars movies, because the Star Wars movies take place "a long time ago in a galaxy far, far away", well

before COVID-19 existed.[citation needed]

Cueball notes that if only Luke had been vaccinated, he would still be a possible risk to Vader. The various vaccines seem to do well to protect recipients from the harsher outcomes of the virus. The vaccines may not completely prevent them from mild infection and potentially then passing it onwards. Luke is young and healthy. Luke is probably less susceptible, if Luke were to be exposed to the virus at any point. Vader's health issues mean that Vader would be in much greater danger from such a respiratory disease without Vader's own personal inoculation. The Emperor is elderly, but probably not at as great of a risk as Vader is. However, the Emperor, too is susceptible if the Emperor were infected.

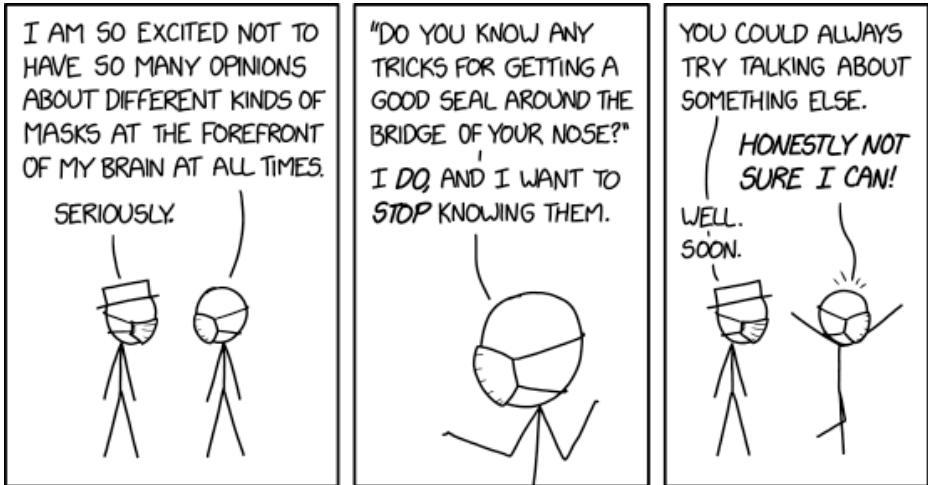
Cueball judges that Darth Vader's mask and breathing apparatus would protect Vader from the virus, a topic that was previously considered in 2367: Masks. The protection is at least to a limited extent. This is not an unreasonable assumption. Vader's suit has allowed Vader to survive the vacuum of space for short periods of time. Cueball concludes that all the characters in this fight need to be vaccinated in order to prevent the spread of the virus. This will be true until the Emperor dies. After the Emperor dies, only Vader needs to be vaccinated.

The title text refers to two separate CDC recommendations. If you are visiting with people from a single household when vaccinated, all at low risk of serious complications from COVID-19, you do not have to take precautions. The precaution that you do not have

to take include physical distancing or masks. If you are visiting with people from multiple households, then it is recommended that you take precautions against the spread of the disease regardless. Cueball is unsure whether or not Darth Vader and the Emperor live in close enough proximity to count as a single household. Whether Vader and the Emperor live in a single household would change how Cueball decides who should and should not be vaccinated. It is unknown, based on the Original Trilogy of Star Wars movies alone, how much time Vader and the Emperor spend in proximity. The "weird black egg thing" refers to Darth Vader's meditation chamber, first seen in *The Empire Strikes Back*, which allows Vader to spend some time outside of his suit.

#2442: Mask Opinions

March 26, 2021



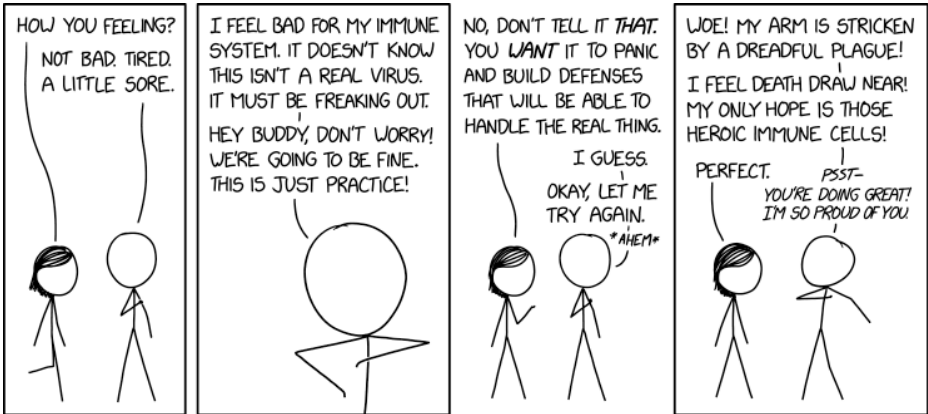
Although regardless of how everything else shakes out, I definitely won't mind if the norm "wear a mask if you're feeling sick" sticks around after this.

Explanation

Explanation section not found.

#2443: Immune Response

March 29, 2021



I don't care whether you win or lose, as long as you have--
...okay, sorry, I'm being reminded I very much care whether
you win or lose. I need you to win, that's very important.

Explanation

This is another comic in a series related to the COVID-19 pandemic.

As with a number of previous strips, Randall has a tendency to anthropomorphize both pathogens and the immune system, envisioning the process of infection and immune response as an epic battle. In this case, he treats his immune system as he would a child trying to accomplish something difficult, and worries about its emotional reaction.

The COVID-19 vaccines (like all viral inoculations) work by introducing viral proteins into the body, causing the immune system to react as if the actual virus were present, creating the antibodies to fight it. As a result, if the actual virus is introduced, the immune system will have the capacity to quickly eliminate it.

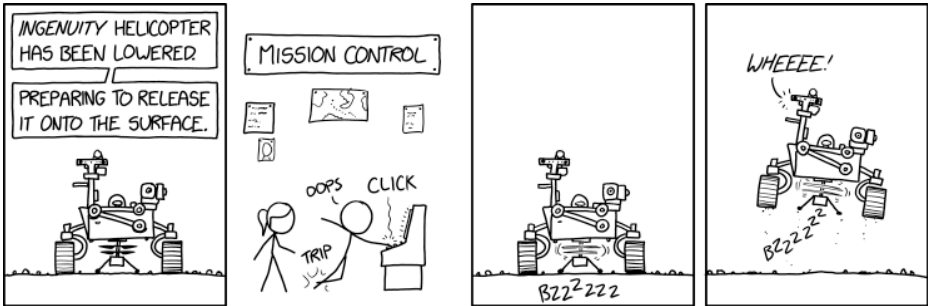
In this comic, Cueball has just received the COVID-19 vaccine and anthropomorphizes this process. He worries that his immune system is "freaking out", as the vaccine causes the body to 'think' it's under attack and respond as it would to a deadly threat. Cueball accordingly tries to reassure his immune system that the threat isn't real. However, Megan reminds him that the "panic" is the entire point, as that's what causes the body to build defenses, which will allow it to handle the real virus. Cueball then switches tactics, melodramatically announcing that the virus is about to kill him, and

encouraging his "heroic immune cells" to save the day. The joke is that the basic elements of their response is accurate: the vaccine is essentially a ruse intended to "trick" the immune system into developing antibodies. However, the immune system obviously lacks a separate consciousness, and can neither hear nor understand their comments,[citation needed] making both reassurance and encouragement entirely moot.

In the title text, Cueball continues to treat his immune system like a conscious entity. Specifically, all of his communications sound like a parent, or other adult, trying to encourage a child who was trying to win a game: giving it a pep talk about how he doesn't care if it wins or loses as long as it has fun. This is a common refrain when parents or other adults try to reassure children in contexts where victory isn't especially important, and where enjoyment is the real goal. Cueball then remembers that this particular event is much more consequential. If his immune system were to 'lose' to the vaccine, that would presumably mean it was incapable of responding properly to the viral threat, meaning he'd be in serious risk of death if he contracted the actual virus. As a result, he corrects himself and states that winning, in this case, is "very important".

#2444: Ingenuity

March 31, 2021



Plot twist: Thanks to [mumble mumble] second-order [mumble] Rayleigh-Taylor [mumble] turbulent [mumble] shear, it turns out powered flight is way **EASIER** on Mars!

Explanation

Ingenuity is a drone-like helicopter deployed to the surface of Mars. It rode on the underside of the Perseverance rover and at the time of publication its protective housing had been released from the rover and it was being prepared for a flight in early April. The helicopter is supposed to take off after the rover fully releases it and clears its takeoff trajectory.

The comic projects what might happen if the mission controllers activated the helicopter early. In this case, the process is approaching the point of detaching the part-deployed Ingenuity. Ponytail and Cueball are present in mission control when Cueball trips and hits a button that clearly triggers the Ingenuity drone to take off. Perseverance, still firmly above/attached is seen to easily ride atop it. The rover exclaims "Wheee!", presumably from excitement or happiness.

In the title text, some character discovers powered flight is easier on Mars, which contradicts our current understanding that powered flight is very difficult on Mars. Mars may have less gravity, but Mars's atmosphere is 1% the density of Earth's. It's so thin that you couldn't move a feather with a fan. This is why the character mumbles his explanation of the science, because they know any explanation doesn't actually make sense.

The total mass of the two vehicles is about 556 times that of the helicopter alone, meaning the unexpected lift

effect 'described' would have to be several hundred times more effective than that anticipated, depending upon the factor of overdesign already built in to avoid an expensive marginal failure. It also seems to be trivially easy to balance the extremely top-heavy loading upon the small solar-panel that tops out the counter-rotating coaxial blades, which adds yet more questions of both the dynamic and structural performance, never mind questions about the available power to accomplish this and the later possibilities to recharge.

The Rayleigh–Taylor instability is a fluid instability that occurs at the interface between two fluids of different densities when the lighter fluid is supported by the denser fluid, leading to the mixing of the fluids due to the growth of perturbations at the interface.

It is not the first time that we have seen a Mars vehicle vastly exceed expectations in these pages.

It is also not the first time a character has caused an incident by tripping and hitting a control panel, though that occurrence had much more dire consequences...

#2445: Checkbox

April 01, 2021

☒ LOADING...

Check check check ... chhecck chhecck chhecck ... check
check check

Explanation

This was the 11th April fools' comic released by Randall. The previous fool's comic was 2288: Collector's Edition, which was delayed two days and released on Friday April 3, 2020. The next became 2601: Instructions released on Friday April 1, 2022 (a regular release day). The comic looks similar to a loading screen. The actual comic (this "loading screen") consists of an animated gif of a checkbox, hence the name.

The frame is replaced with an interactive panel. In the center is a check box, which clears itself immediately when checked. In the bottom right is a mute button, which begins muted. By unmuting, and changing it to a loudspeaker, sounds are played when the check box is checked. This was the second comic with audio on xkcd. The very similar April Fool's comic from the next year, 2601: Instructions, used audio, too. It also had only one element in the center, but not a check box, but a radio button.

Under the checkbox is a scrolling visual representation of the timing and duration of clicks in the check box, which also produce matching beeping sounds when unmuted. The representation consists of a dot for a short press, or a bar for a longer press. All long presses are represented by a bar of a pre-determined length; in other words, a longer press does not result in a longer bar.

By varying between brief and long presses, and brief and

long intervals between presses, it is possible to enter characters in Morse code. The check box then begins operating by itself, producing sounds which can be decoded as Morse code. These responses are also printed in the browser's JavaScript console in both plain text and a textual representation of Morse code. If left without any initial input for 30 seconds it would send the message CQ (meaning "Seek You").

The title text hints at the use of Morse code in the comic; interpreting the "check" as a Morse code dot and the "chhecck" (a long check) as a Morse code dash gives ...---..., which is the Morse code for "SOS", the international distress signal. Incidentally, inputting the SOS signal gives "YOU TOO?".

For the majority of inputs, the check box responds with a random selection from the following list:

- COME AGAIN
- HUH
- NOT FOLLOWING
- SAY AGAIN
- TRY THAT AGAIN
- WHAT

Some keywords, however, have special responses.

Unique header text[edit]

This comic has a unique header text, see the details here. Its header is:

Read Max's blog post on development of the comic.

#2446: Spike Proteins

April 05, 2021



Ugh, it's stuck to my laptop. It must have bound to the ACER-2 receptor.

Explanation

This is another comic in the COVID-19 series related to the COVID-19 pandemic.

This is also another comic about the current vaccine against COVID-19. A vaccine is designed to provoke an immune response from the body of the recipient, which "trains" the immune system to attack actual viruses (or bacteria). For COVID-19, the spike protein, necessary for the virus to bind a receptor on human cells and invade them, is the key protein for an immune response. Almost all vaccines approved for human use pre-COVID actually contain either inactivated pathogen (e.g., flu vaccine), live but safe pathogen variants (e.g., measles), or some protein from the pathogen that the immune system can respond to (e.g., pertussis). The four COVID-19 vaccines approved in the United States or the European Union as of the date of this comic, however, are all a relatively new type of vaccine that instead cause human cells to temporarily produce spike proteins, which the immune system then "learns" to attack. The Oxford-AstraZeneca and Johnson & Johnson's Janssen vaccines use a technique first approved for the July 2020 Ebola vaccine, in which a genetically modified adenovirus is used to deliver DNA to the nuclei of the vaccine recipients' cells, which convert the DNA to Messenger RNA (mRNA). The recipients' cells then use the mRNA as instructions to produce spike proteins. The Pfizer BioNTech and Moderna vaccines are of an even newer type: mRNA vaccines, which directly inject

the mRNA into the body for the cells to use, and never have to enter the cell nuclei.

Beret Guy, in his usual fashion, misunderstands how reality works, then reality alters to fit his view of it.

After receiving the vaccine, as he informs Cueball and Megan, he claims he will now go away to make spike proteins. For him, this literally means that he (not his cells) will build them, by unexplained means. When he returns he is carrying his constructed protein, which is roughly 8 orders of magnitude larger than the normal version, and also appears to be dripping. He then drops it on the desk, where a laptop is being used. Cueball part-closes his screen to try to prevent the mass from landing on it - though he's only partially successful.

When a normal living body is coerced into making a spike protein, they are microscopic particles that distribute internally around the body to provoke an immune response. Beret Guy's macroscopic version provokes an understandable response of both disgust and confusion from both Cueball and Megan, who choose to ask why it is so wet. Proteins are highly hydrated molecules where water — through the moderation of its presence and absence in specific locations — plays a central role in shaping the structure and function of the protein (although it is not clear how Beret Guy knows that the spike protein should be hydrated since this is his first try). Though, of the many questions that might have been asked, it is not an entirely unreasonable snap reaction.

Beret Guy remains typically oblivious to the fuss he causes. His enthusiastic intention, apparently, is to leave his first proud creation there as he departs to construct further examples. They will likely be no less unwelcome.

Anything damp and squidgy (as this creation seems to be) would not be welcome around a laptop, for a number of reasons, and Beret Guy seems to have made a particularly messy contact with the part of the case where most such devices are likely to have clusters of heat vents or unruggedized ports/connections that may not react well to the ingress of liquids.

The title text is a pun on Acer, ACER2, and ACE2. Acer is a brand of computers including laptops. The ACE2 receptor, is an entry point on a cell to which the SARS-COV-2 virus attaches during the process of entering the cell. ACER2 is a real enzyme in humans which, although unrelated to ACE2 or SARS-COV-2, may also help bind the pun together.

#2447: Hammer Incident

April 07, 2021



MAN, NASA IS REALLY ON MY CASE ABOUT
THE JAMES WEBB SPACE TELESCOPE.

I still think the Cold Stone Creamery partnership was a good idea, but I should have asked before doing the first market trials during the cryogenic mirror tests.

Explanation

The James Webb Space Telescope (JWST) is a space telescope created to be the successor of the Hubble Space Telescope under construction at time of publishing and launched December 25, 2021, though in 2014: JWST Delays, xkcd predicted its launch would actually occur during late 2026.

It's implied that Cueball dropped a hammer on the mirror of the JWST and broke it. In superstition, breaking a mirror causes seven years of bad luck. The cost estimate for the JWST is currently US\$10 billion, and Cueball is at a NASA official hearing for breaking this very expensive piece of equipment, no doubt costing NASA (and thus the nation) hundreds of millions of dollars more for repair work. However, Cueball is more concerned about personally experiencing seven years of bad luck.

In actuality the mirror panel is not made of glass, so it's likely that a dropped hammer would dent and distort the panel rather than shattering it. Presumably Cueball's hammer drop would damage or destroy only one mirror panel out of the JWST's eighteen panels. (If he had destroyed the entire telescope, he may have been facing $7 \times 18 = 126$ years of bad luck, and the damage costs would be much, much higher. Then again, this depends on the altitude that the destruction happened.) Even breaking a single panel would likely be very expensive because it would require extremely accurate machinery and

extensive calibration tests to make and install a replacement panel, especially because the back of JWST's mirrors are made of beryllium. Beryllium is expensive to purchase, since it is relatively scarce, and is very hard and abrasive, so making things out of it is difficult (and expensive due to the specialized machinery required and the precautions necessary to prevent inhalation). Breaking a beryllium mirror would lead to dust formation; single exposures to beryllium dust can cause acute beryllium poisoning and massively increase the risk of lung cancer, which is very bad luck on behalf of Cueball. In addition to the property damage, Cueball is probably liable for injuring his coworkers, which is probably the main reason why the NASA workers are so angry at him because human lives are more valuable than mere money.[citation needed]

The title text refers to the Cold Stone Creamery, a chain that mixes ice cream with various other ingredients, such as fruit or candy, in front of the customer before serving it. The usual surface for mixing is a piece of granite which is kept cold (about -10°C). It's implied that Cueball had tried mixing his ice cream and flavorings in the style of Cold Stone Creamery on the JWST mirror, which is also kept cold -- in fact much colder, as it's cooled to as low as 7 K (-266°C , or -447°F). If Cueball had mixed ice cream this way on the JWST, he would likely have scratched and/or stained the surfaces on the telescope and perhaps have gotten gunk into the instrumentation, and possibly, due to the localized temperature differential from ice cream hundreds of

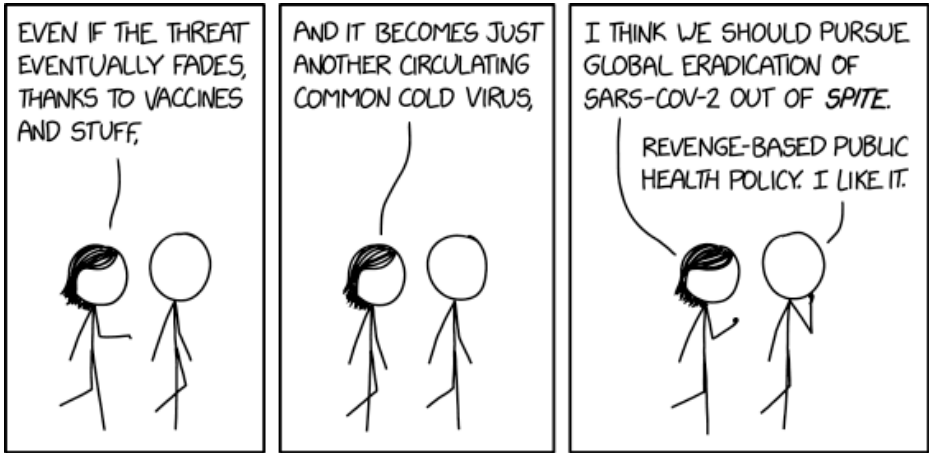
degrees warmer than the material, promoted damaging distortions or fractures -- hardly the 'good idea' mentioned in the title text. (It also would not have worked: at sufficiently low temperatures, ice cream hardens and cannot be mixed.)

The bad luck from breaking a mirror is also referenced in 1136: Broken Mirror.

A similar space-related hearing is shown in 2148: Cubesat Launch.

#2448: Eradication

April 09, 2021



When you get to hell, tell smallpox we say hello.

Explanation

This is another comic in the COVID-19 series related to the COVID-19 pandemic.

Megan and Cueball are discussing the possibility of SARS-CoV-2 eventually becoming "another circulating common cold virus". This was considered to be a serious possibility, as a combination of vaccines and acquired immunity cause most people to have some degree of immunity as they age. This is particularly likely because SARS-CoV-2 was not believed to pose significant risk to small children, and if most people are infected with it in childhood, they'll likely be immune as adults. Multiple other coronaviruses are common in the human population, and fall under the category of "the common cold", causing only minor and temporary symptoms, with little serious risk for most people.

If SARS-CoV-2 does transition to being a minor disease, there will be little reason to continue focused eradication efforts, because the ongoing harm will be too little to justify such efforts. It's extremely difficult to wipe out a virus altogether, as it requires every human population to be either isolated from the disease, or vaccinated until herd immunity is achieved. There are only two viruses which have been totally eliminated in the wild: Smallpox and rinderpest, and rinderpest infects only cattle and other ruminants, not humans. The elimination of smallpox was one of the greatest public health accomplishments of the 20th century, and resulted from

an aggressive and ambitious global vaccination effort. Smallpox is now considered to be extinct in the wild, with only a small number of samples still preserved in government labs.

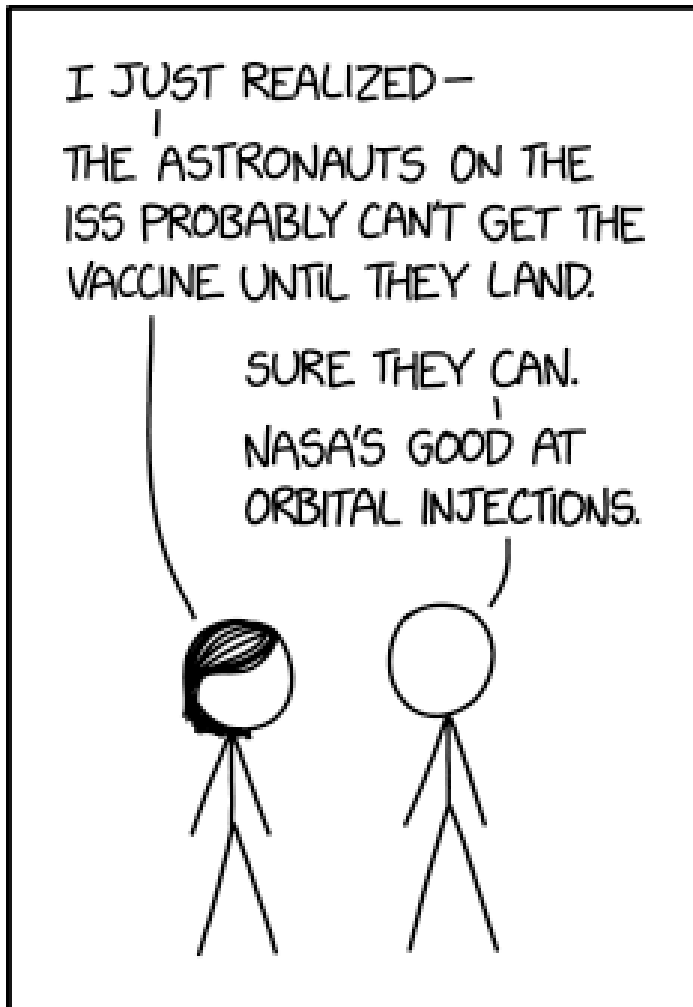
Where diseases continue to be dangerous, ongoing global efforts are made to eliminate them entirely (polio, measles and rubella are currently targets of such programs). If a disease ultimately becomes more or less harmless, its elimination is less of a priority.

The joke of this strip is that, in the aftermath of the COVID-19 pandemic, Megan feels so much rage and ill-will toward the disease that vaccination efforts are no longer only a matter of protecting health, but an expression of hostility toward the virus. Her argument is that, even if global elimination efforts are no longer justified by the danger of the virus, they should be pursued "out of spite". Like many other strips in this series, the characters tend to anthropomorphize the virus, treating it as an intelligent and sentient enemy, rather than mere force of nature. Given that mindset, the idea that the virus could cause so many deaths and so much disruption, and then continue to exist without consequence, would upset many people. Cueball agrees with her perspective, approvingly referring to it as "revenge". Cueball has also previously shown a merciless attitude towards endemic infections, even those that aren't particularly deadly, and so the idea of eliminating one entirely would probably appeal to him on its own merits.

The title text refers to the aforementioned extinction (in the wild) of smallpox. This is the type of line one might see in fiction, delivered to someone who is about to be killed, taunting them about the death of one of their friends or associates. The line treats the virus like a villain in an action movie, and revelling in the fact that we're finally going to kill it.

#2449: ISS Vaccine

April 12, 2021



Because they orbit the Earth every 90 minutes, some astronauts should try to argue that, due to CDC regulations and time zone technicalities, they should be able to get their second dose just 30 or 40 hours after

their first.

Explanation

This comic is another in a series of comics related to the COVID-19 pandemic, specifically regarding the COVID-19 vaccine.

Megan has just realized that the astronauts on the ISS (the International Space Station) probably can't get a vaccine against COVID-19 before they land. That is, it will not get shipped up to them.

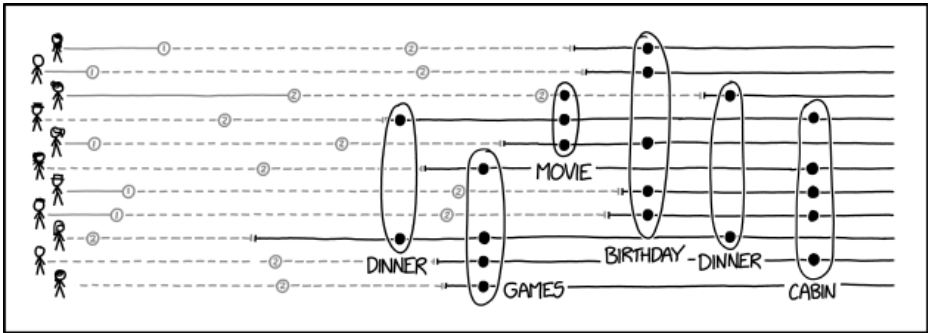
This can be a concern because their immune system is impacted by extended stays in space. So when they come down again they may need to stay in quarantine longer, as the vaccine is not fully effective the first few weeks after administration. There could of course also be concern about getting COVID-19 while in space, but this is very unlikely due to the quarantine measures and other security measures taken by NASA and their Russian counterpart, Roscosmos. See this article with more details on these facts: What NASA is doing to keep COVID-19 off the space station.

Cueball's reply, "NASA's good at orbital injections", is a pun on "orbital injection", also called orbital insertion, which is the adjustment of a spacecraft's momentum that puts it into a stable orbit around a planet, moon, or other celestial body. Space agencies like NASA do this routinely on spaceflight missions. Getting an injection of a COVID-19 vaccine while in orbit aboard the ISS could also be called orbital injection, hence the pun.

The title text refers to the fact that, because the ISS orbits the Earth every 90 minutes, the people aboard it experience a day in that time, seeing a sunrise and sunset and crossing the International Date Line on the ground. One interpretation of this might be that 90 minutes on the ISS are equivalent to a day on the ground, making the people on board due for the second dose of the Pfizer vaccine (normally 21 days) or the Moderna vaccine (normally 28 days) after 31.5 or 42 hours, respectively, which Randall rounds to 30 or 40 hours. In reality, rather than tracking the local time of the territories it passes above, the ISS follows Coordinated Universal Time.

#2450: Post Vaccine Social Scheduling

April 14, 2021



POST-VACCINE SOCIAL SCHEDULING

As if these problems weren't NP-hard enough.

Explanation

This comic is another in a series of comics related to the COVID-19 pandemic, specifically regarding the COVID-19 vaccine.

The comic shows a timeline of a multitude of (presumably) friends and acquaintances getting two doses of the SARS-CoV-2 vaccine. Due to the recommended delay between shots, as well as the few weeks needed to build antibodies after the second shot, planning get-togethers becomes complicated by who is free to meet, or not yet.

The diagram is some form of Scheduling Diagram, maybe akin to a Gantt chart, which helps to coordinate the status of several individual 'processes' (personal vaccination schedules) and demonstrate where dependent activities (meet-ups) are mutually possible.

Eventually, everyone can start getting together, but during the time where some people have only received one, neither, or only got the second recently, the scheduling is complicated. The complication is increased by the fact that people who have received one or two doses of vaccine, but haven't gone through the whole waiting period, can be expected to have some protection, but possibly not full protection (as represented by the dashed line). In that case, there's the added question of how important it is that the person is at an event, and how much risk the people involved are willing to tolerate.

This may be the reason for the "movie" set, in which all participants will have received both doses, but one will not have completed the final waiting period.

The title text references NP-hardness, a theme that has come up in past comics. NP-hardness describes a particular level of computational difficulty. Scheduling problems are normally NP-hard. But when extra challenges such as having to deal with whether or not people are vaccinated they become even more difficult.

In this case though, Critical Path dependencies seem trivial enough. Events (vertical lozenges across the dot-marked timelines of those included) are as trivial to validate as possible for those selected to attend. Fixed events in time can be scanned to show all those allowed to participate at that moment. Movable events can be rescheduled until (enough of) those hoped to be included are 'valid'. Complications may arise for those whose presence relies upon the status of others potentially attending, or the need to maintain time between two events (in either order) with part-shared attendees as a precautionary 'cool-down' isolation. It is not obvious that either of these issues factor in, any more than basic scheduling conflicts would.

The third person is scheduled for a movie before being fully vaccinated may be a direct reference to 2441: IMDb Vaccines, discussing the number of people that needs to be vaccinated to record a particular scene. Other than each line's identifying portrait (which are not of the Throne Room characters) no explicit age/vulnerability

information is given to justify this, presumably the chart's users are aware of the specifics.

The third person in the table is included in a movie viewing (for which masks could be worn) shortly after their second immunization, but not included in the dinner group until the full benefit of the vaccine takes hold. CDC guidelines permit vaccinated individuals to visit inside a home or private setting without a mask with one household of unvaccinated people who are not at risk for severe illness. Therefore the movie gathering conforms to CDC recommendations provided that the single unvaccinated person is not at increased risk of severe illness and the movie is in a home or private setting.

The third person in the table appears to have received the second shot twice. This is possibly a reference to 2422: Vaccine Ordering. Another interpretation is that she lied about her first dose being her second dose to be invited to the movie.

#2451: AI Methodology

April 16, 2021



We've learned that weird spacing and diacritics in the methodology description are apparently the key to good research; luckily, we've developed an AI tool to help us figure out where to add them.

Explanation

The joke in this comic is that the people are using artificial intelligence (AI) without understanding how to, and that by doing this the research concerned is at best unreliable and possibly deliberately compromised, as in 2494: Flawed Data. The researchers acknowledge that their approach is risky and requires extra verification, but repeatedly use equally or more unreliable AI-based solutions to these problems. Therefore, their problems are likely as bad as they ever were and any other team using one of their verification tools is likely to experience similar unreliability. For an introduction to machine learning, you can visit <https://fast.ai/> .

Original research[edit]

The first comment, that "some have questioned our AI-based methodology", refers to difficulty verifying the correctness of AI-based processing. A model (a program which solves a problem with AI-based statistical analysis) may appear reliable when it is instead insufficiently tested. Models are liable to experience issues due to lingering influences from its training data or a bad algorithm reducing the quality of the investigation. It is therefore necessary for research using such models to demonstrate that those models have been tested well enough that their results are likely to be useful. Frequently, additional tests are performed after training to confirm that the model can handle data collected in a different way to the data used to train it.

Classifier of methodology quality[edit]

Cueball seeks to reassure his audience by quantifying the quality of his methodology. He does this by creating yet another AI to rank methodologies. This approach is unlikely to instill confidence for a variety of reasons:

- The quality AI and original research AI were written by the same team. If the original research AI was ill-designed, the quality AI probably shares design problems with it.
- The specific kind of model created is unlikely to be the correct one. Cueball calls this a classifier, which is frequently a type of model which assigns an input into distinct mutually exclusive categories. For example, a classifier might be used to determine what language a chunk of text is, given that the chunk is in only one language. However, quality is a continuous aspect of the data. A classifier of methodologies is likely to sort them into "bad", "mediocre", and "good" categories, whereas an effective model should have the ability to give more precise grades. The choice of a classifier may indicate that Cueball doesn't know which types of models to use.
- The training data for this quality AI is not mentioned. If, for example, the team's previous research is used as examples of good methodologies, the AI is likely to judge all methodologies from them as good as well.
- A methodology section refers to quality of writing and is a specific section of a research paper. A good methodology section would accurately and clearly explain what he did, but does not mean the research methodology itself was valid. Cueball doesn't indicate whether he believes his model is trying to analyze the quality of the methodology described, but in any case this is nearly impossible for existing machine learning.

- An AI which attempts to judge a methodology section is receiving a great deal of input which is difficult to process. It would have to use natural language processing to understand the writing in the methodology section and would also require a lot of specialized knowledge about the subject matter to judge the quality. This would require artificial general intelligence (AGI), which has not yet been achieved. Since the AI does not have the ability to fully understand complex research, it will likely use unimportant details to judge the methodologies.
- The ranking AI heavily favors the methodology of Cueball's AI, and may be biased. It shows a normal distribution, with a singular outlier to the far right with an arrow above. It can be inferred (from the arrow) that this data-point represents the AI's methodology. It is a significant outlier, and as such it is probably not an accurate representation of Cueball's AI. Alternatively, this could be taken as AI 'nepotism', where Cueball's methodology AI is more likely to select AI-based approaches over others. This type of algorithmic bias is mentioned in 2237: AI Hiring Algorithm.

Spacing AI (from title text)[edit]

While there are many red flags in the original AI and quality AI, it is theoretically possible that they operate as Cueball claims. The title text's comments about spacing and diacritics prove that this is not the case and that the quality AI, at least, is completely broken. AI models are given input in various complex ways and determine based on statistical analysis which details are important. Such models can easily find details in the training data which correlate with correct answers but make the resulting model useless.

For example, a research team once created a model which was

given medical information to determine how likely a patient was to have cancer. The model was trained on existing patient records and the team planned to use it on new patients. However, the original model did not use the medical information but instead simply checked the name of the hospital--a patient at a hospital with "cancer center" in the name was likely to have cancer. The model had identified a data point which correlated with the desired answer, but this correlation was not useful for the intended purpose. The model concerned was discarded and a new one created without the hospital name.

In this case, the methodology sections are text written by humans, which can contain various artifacts of the writing process. These can include details like how the user chose to insert spaces, word usage, spelling, or diacritic marks which are optional in English (e.g. naïve versus naïve). It appears that the training information identifies certain patterns which correlate with "good" methodologies. This indicates a few more problems for this research team:

- Their AI is using pointless details to decide on the quality of methodology sections, so it is useless.
- They haven't recognized that it's useless, so their other AI is probably fatally flawed.
- The spacing information is correlated strongly with good methodology, which implies that they probably don't have very many different sources for their training data. Their sample size is too small and the AI, even if it was improved to ignore this information, needs more data to have a chance at being useful.

It should be noted that this comic was released about a year and a

half before the release of ChatGPT and a new revolution in AI, making the various points in the comic seem out of date by modern standards.

#2452: Aviation Firsts

April 19, 2021

	<u>EARTH</u>	<u>MARS</u>
FLIGHT	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
LANDING	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
CONTROLLED LANDING	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
CONTROLLED POWERED FLIGHT	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
LOOP	<input checked="" type="checkbox"/>	<input type="checkbox"/>
IN-FLIGHT MEAL	<input checked="" type="checkbox"/>	<input type="checkbox"/>
PLANETARY CIRCUMNAVIGATION	<input checked="" type="checkbox"/>	<input type="checkbox"/>
ENORMOUS WOODEN AIRCRAFT BUILT BY A RECLUSIVE BILLIONAIRE THAT FLIES EXACTLY ONCE	<input checked="" type="checkbox"/>	<input type="checkbox"/>
HIJACKING BY SOMEONE DUBBED "D.B. COOPER" WHO DEMANDS MONEY AND THEN JUMPS OUT MID-FLIGHT TO AN UNKNOWN FATE	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Mile High Club membership ☐☐ Discovery of parts of
Amelia Earhart's skeleton ☐☐ Mid-flight incident that
results in safe landing on the Hudson River ☐☐

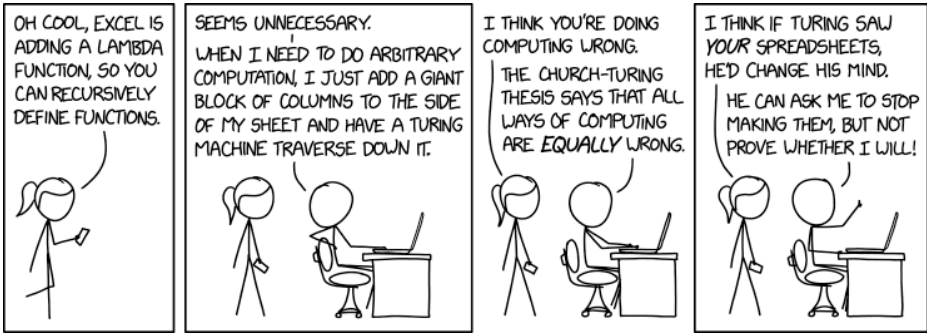
Explanation

This comic reflects the Ingenuity probe's first flight on Mars. Now that Ingenuity has completed its first flight, Mars can be counted among planets with controlled powered flight. The preceding milestones in this list were completed by the first space probes to reach and then land on Mars. Flight, landing and controlled landing were variously achieved by some or all of the prior landers, depending upon your definition of flight, but certainly by the Skycrane element used in landing both Curiosity and Perseverance rovers. These may not have qualified as controlled powered flight as they only used their power to control the landing, before flying off again under power without any more precise control than that needed to intentionally crash elsewhere.

The remaining milestones have only been completed on Earth, if at all, and also grow more bizarre and more specific further down the comic and extending into the title text.

#2453: Excel Lambda

April 21, 2021



Extremely rude how Turing's later formulations of the halting problem called me out by name specifically.

Explanation

Cueball is computing and Ponytail criticizes him in a way that is reminiscent of the Code Quality series, although not as harsh. Cueball has lots of strange computer problems, and this will most likely result in another one.

The comic begins with Ponytail finding out that Microsoft Excel is adding a lambda function to their function library. This was announced by Microsoft for Beta users in December of 2020. A lambda function is a fundamental mathematical structure that can be used to define all possible computations, in what is known as lambda calculus. They are commonly found in programming languages such as Lisp, Python, and many others. A lambda function is also called an anonymous function because in most languages it can be passed to other functions (including another lambda function) without needing to be given any formal name.

Finding that Excel is adding a lambda function pleases Ponytail. Cueball claims that the lambda function is unnecessary, as when he needs arbitrary computation he just adds a block of columns to the side of his sheet and has a Turing machine process it. This would technically work as lambda calculus is formally equivalent to Turing machines. People have created Turing machines in Excel, although not for practical purposes.

Ponytail finds his solution absurd and is convinced Cueball is "doing computing wrong". But he claims that

all computing is equally wrong, citing the Church-Turing thesis, a hypothesis which says that a function can be computed by executing a series of instructions if and only if that function is computable by a Turing machine. A classical Turing machine uses an infinitely long strip of tape as its memory; for Cueball, the large Excel column acts as the "tape". All ways of computing are "equally wrong" since, according to this thesis, they can all be translated to or from a Turing machine.

Ponytail and Cueball appear to have different ideas of 'computing'. Ponytail, like most programmers, probably includes efficiency and readability as important characteristics of 'doing computing right'. Cueball appears interested only in computability, a more theoretical point of view than Ponytail's.

Ponytail then says that Turing would change his mind if he saw Cueball's spreadsheet, presumably because of the extreme complexity of Cueball's code in the spreadsheet. Cueball's final statement is that Turing could ask him to stop, but would not be able to prove if he actually will stop.

Cueball's final statement is a reference to the halting problem mentioned in the title text. It is the problem of determining whether a given Turing machine will halt. The problem has been shown to be undecidable, i.e., it is impossible to build an algorithm that computes whether any arbitrary Turing machine will halt or not. Because of the way Cueball has behaved, he has been specifically

mentioned in Turing's later formulations of the halting problem. Cueball finds this very rude. This is of course a joke, since Turing has been dead since 1954, presumably long before Cueball was born. But it would be crazy indeed if a scientist became so mad at a person that they would mention this person by name in their formulation of a serious problem.

Over-complicated spreadsheets were also mentioned in 2180: Spreadsheets.

#2454: Fully Vaccinated

April 23, 2021



REMEMBER, ONCE YOU'RE
FULLY VACCINATED, THE CDC
SAYS YOU'RE FREE TO VISIT
OTHER PEOPLE'S HOUSES.

"You still can't walk into someone's house without being invited!" "What? Oh, I see your confusion. No, this vaccine is for a bat VIRUS. I'm fine with doorways and garlic and stuff."

Explanation

This comic is another in a series of comics related to the COVID-19 pandemic, specifically regarding the COVID-19 vaccine.

The Centers for Disease Control and Prevention (CDC) has stated that once people are fully vaccinated, they are able to visit other people's houses (and not risk spreading/catching coronavirus). The implication, of course, is that you can visit people that you would also have visited before the outbreak. The humor in this comic comes from Megan who is just going to visit a random stranger's house. She explains this is okay because she is fully vaccinated, telling the person in the house that she is two weeks past her second dose. This was part of the topic of the last vaccine comic 2450: Post Vaccine Social Scheduling.

Restrictions to socializing, brought in as various governments reacted to the emergent COVID-19 pandemic, often disallowed or discouraged visiting family, friends, etc, beyond a mutually isolating 'support bubble', which meant that many house visits that might have occurred beforehand were no longer advisable. With the development and distribution of vaccines, and the eventual receiving of a second dose as applicable, the rules have been modified to allow those vaccinated to once again resume some degree of their prior outgoing behavior where the risks have been mitigated.

In this instance, though, Megan has taken the advice even further. Rather than opening back up to a situation closer to the 'old normal', she has taken it as an official sanction to exceed the old social limits and pester complete strangers. Alternately, this is what she always used to do, and only stopped 'for the duration', this unlucky householder being (one of) the first to be subjected to this 'guerilla visiting' now that there seems to be no reason not to continue.

In the title text, the owner of the house explains to Megan that just because she has been vaccinated she just can't enter into someone's house without being invited — a commonly understood form of property law.

But due to the vaccine type Megan thinks the owner has mixed this up with a commonly understood element of vampire lore, that vampires must be invited into a home before they can pass through the doorway.

In vampire lore, vampires are often able to transform into bats, and these two are thematically associated with each other. Since the coronavirus is likely a bat virome that has entered into humans, Megan misunderstands the owner's objection to her entry, believing that the homeowner thinks that she has become a vampire. (The virus, and thus elements of the vaccine, having ultimately originated in bats and therefore 'possibly' actual vampire stock.)

Megan thus begins to explain that the vaccine works on a bat virus and has nothing to do with bats. And since she

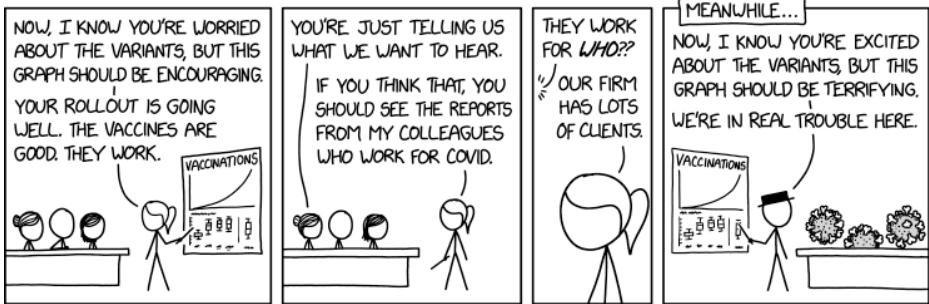
is thus not a vampire she has no problems entering a doorway uninvited, and further explains that she is also not repelled by garlic or other classic weakness of vampires. Vampire lore states that they are repelled by garlic, crosses, holy water, sunlight, and wooden stakes through the heart (the last being a problem for humans in general, vampiric or otherwise).

The owner is attempting to explain that Megan does not have the legal or moral right to enter simply because she is vaccinated, but this seems to not register with Megan.

Doing ridiculous things that were never allowed, even normally, after being vaccinated or low-risk, was also the theme of 2434: Vaccine Guidance. 2391: Life Before the Pandemic also dealt with a similar theme, with Cueball and Megan reminiscing about activities they missed doing but which had not been allowed or possible before the pandemic.

#2455: Virus Consulting

April 26, 2021



All our teams make an effort to stay optimistic, but I will say that once our virus division saw the vaccine efficacy data, they started asking for payment up front.

Explanation

This comic is another in a series of comics related to the COVID-19 pandemic, specifically regarding the COVID-19 vaccine.

This comic imagines a scenario where Ponytail works for a consulting firm, which offers advice about viruses, specifically COVID-19. Ponytail tells a panel of people (the government?), consisting of Hairbun, Cueball and Megan, that though they are worried about COVID-19 variants, the fact that the number of people vaccinated is increasing considerably is a good sign. Hairbun then accuses Ponytail's firm of simply "telling them what they want to hear", accusing her firm of giving them false hope to make them keep retaining her firm.

The punchline comes in the final panel where it turns out that Ponytail's colleague, Black Hat, is consulting a different set of clients, which are the viruses themselves. He presents the exact same graph to the viruses and gives them the opposite message: though COVID-19 variants seem to be exciting to them, vaccination numbers are terrible news to their propagation and survival. This repeats the idea of 2287: Pathogen Resistance where the pandemic is seen from the virus' perspective. As in that previous comic, it is the virus that is in a lot of trouble, which is another way of saying that humanity stands a good chance of surviving this situation. (That humanity will survive is also good for the virus, which needs living humans so that it can spread.) This is not the first time

that Black Hat has given advice to natural disasters that can kill humans, see 1754: Tornado Safety Tips.

The fact that another member of Ponytail's firm is telling clients that they should be worried is what Ponytail refers to when claiming that her firm does not simply tell clients what they want to hear.

Secondarily, the comic is making fun of the perception that consulting firms will offer their services to whoever can pay, even if they are harmful to society, a perception with some basis in fact.

Around the time of the comic, several SARS-CoV-2 variants, commonly called "COVID variants", had been in the news. The SARS-CoV-2 virus had already been seen to have mutated into many different strains, some of which spread more easily among humans. It was still unknown whether the different variants have a greater individual fatality rate. The contemporary SARS-CoV-2 vaccines from Pfizer-BioNTech and Moderna as well as the Regeneron therapeutic monoclonal antibodies all effectively protect against at least the New York (Lineage B.1.526), South African (Lineage B.1.351), and U.K. (Lineage B.1.1.7) variants according to two recent study preprints released April 22, 2021. Further research and peer review was ongoing.

Since the original date of this comic, the common practice changed from describing variants by geographic origins. Variants Of Concern and Variants Of Interest might indeed have arisen spontaneously in the place

where their changes had first been detected in (or most directly traced back to), but there was no good reason to perpetuate a stigma upon any particular region. Instead, greek letter-names were applied to the major variations. (For the above noted versions "New York" became Iota, that South African version was identified as Beta, and U.K. (or "Kent") had been assigned as Alpha.) Not all lettered VOCs/VOIs became major players on the global stage, but by November 2021, the 'alphabet' had reached Omicron (the fifteenth letter but the thirteenth actually used, having just skipped the letters "nu" and "xi" to avoid undesirable sound-alike associations) and, while there is still much to study, this seems to have the capability of greater transmissability and retransmissability (even in the vaccinated) but, initially at least, also lower illness/hospitality/mortality rate. All these factors have reinforced the potential for the Omicron variety to spread more easily in the human population, as more of an endemic than a pandemic, and thus also to dominate the field against its fellow viral variations.

(The "BA.2" sub-variant of Omicron has been seen to be again more dangerous and resistant to preventative/therapeutic treatment than the prior Omicron but, as of April 2022, calls by some to give it a Virus Of Concern letter (probably "Pi") have not yet been acted upon.)

Possibly, with hindsight, this actually suggests that Black Hat's caution (and perhaps subsequent advice) has been taken on board by the respective clients. On the other

hand, it could be equally true that governments are just becoming more blasé, or just overly weary of prioritizing lives over money, and are no longer fulfilling the original good practice. But all this is in the future, for the comic, and even this explanation doesn't yet know how it will turn out.

Back in the original comic's time, the title text notes that the firm's "virus division" (the group advising the viruses themselves) has started to get worried that their jobs are becoming obsolete, due to vaccine efficacy. Thus, they are demanding to be paid "up front", before consulting/advising services have been rendered to their clients. Dependent upon the expectations of each party, payment can be asked for "up front", deferred for invoicing once services have been rendered, or a combination of the two. The weaker party to a contract may need to submit their transaction, or a guarantor, before the other spends too much effort in fulfilling their side of the contract.

#2456: Types of Scientific Paper

April 28, 2021



Others include "We've incrementally improved the estimate of this coefficient," "Maybe all these categories are wrong," and "We found a way to make student volunteers worse at tasks."

Explanation

In this comic, Randall satirizes scientific papers by claiming they all (or at least the large majority) fall into only a small number of categories, which he describes with somewhat humorous generalized titles. This comic may be a jab at mainstream news and their handling of scientific announcements; journalists are eager to report on what could turn out to be a scientific breakthrough even if it's very similar to stories they've already published about similar papers that turned out to be somewhat mundane. It may also relate to how some scientific findings follow certain patterns.

#2457: After the Pandemic

April 30, 2021

THINGS I WILL NOT MISS ONE BIT AFTER THE PANDEMIC	THINGS I HOPE STICK AROUND AND BECOME NORMALIZED
WEARING MASKS EVERYWHERE	WEARING MASKS WHEN YOU'RE FEELING SICK, BECAUSE IT'S AN EASY WAY TO TELL PEOPLE TO GIVE YOU SPACE, AND ALSO GETTING COUGHED ON IS GROSS

I'm looking forward to having to worry a lot less about covid, but wouldn't mind if we worried a little more about giving each other colds. Colds are bad!

Explanation

This comic is another in a series of comics related to the COVID-19 pandemic.

There is no hidden humor in this comic, it simply states an opinion. Randall is saying that he is looking forward to not having to wear a mask everywhere after the pandemic is over. Mask mandates were a common way various organizations reduced the spread of Covid-19. Now that the vaccines exist, people are assuming that these mask mandates will soon end, and in many jurisdictions they have already.

However, Randall hopes that people will continue to wear a mask when they are sick, as is common in many East Asian countries. This lets other people know the person may be sick, or trying to avoid becoming sick, so they can give the person extra distance. Wearing a mask reduces the spread of infectious droplets when one exhales or coughs, and reduces exposure to droplets from others. Both features help reduce the spread of communicable diseases. Also, Randall thinks other people coughing on him is gross, as do most people.

Masking when ill would help reduce influenza, tuberculosis and colds. The flu is a deadly disease that usually kills tens of thousands of people each year.

People with less common diseases, like tuberculosis, may be more likely to wear a mask if mask wearing becomes

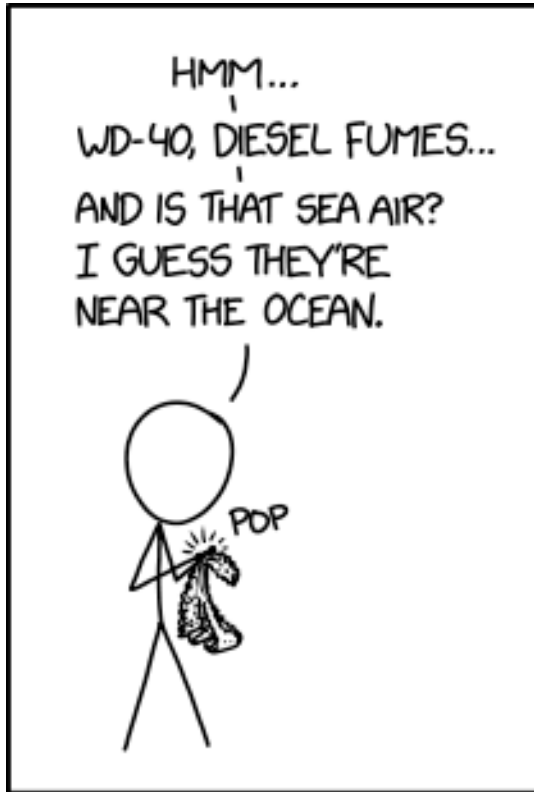
more common, so they don't feel as conspicuous. For less severe illnesses and less vulnerable populations xkcd's wish may not be such a good idea, as every cold - albeit unpleasant - constantly trains the immune system and keeps it alert.

The title text continues this line of reasoning by saying Randall wants to worry less about COVID-19, but hopes people would worry more about colds. Colds are generally mild and might cause someone to spend a few days home sick from work or school. However, colds cost tens of billions of dollars annually in the US. Costs include the value of lost productivity at work or school, time spent caring for the sick, cost of doctor visits and medications. Inappropriate treatment of colds with antibiotics is common, and contributes to the rise of antibiotic resistant bacteria, and clostridium difficile infections..

Randall has made a specific corona comic targeted at colds before: 2306: Common Cold. And in 2015 he probably had a severe cold (or more than one) as he published these two comics 1612: Colds and 1618: Cold Medicine in December 2015.

#2458: Bubble Wrap

May 03, 2021



IF YOUR SENSE OF SMELL IS
GOOD ENOUGH, POPPING BUBBLE
WRAP GIVES YOU A TOUR OF
A BUBBLE WRAP FACTORY.

I think of myself as the David Attenborough of factory mailing equipment.

Explanation

Bubble wrap is packing material made by melting two sheets of plastic together with little pockets of air (the "bubbles") spread throughout the surface. It is wrapped around fragile items for moving or shipping because the air pockets act as a cushion if the item(s) within are struck or shaken. Many people enjoy popping bubble wrap as a mindless hobby, perhaps due to the tactility and other sensations of each bubble makes as it bursts.

The premise behind this comic is that the air inside each bubble comes from the factory where it was made, and thus as each bubble is popped that air — along with anything in it — is released. If one had a very sensitive sense of smell, one could detect unique odors present in the factory at the time not present where you are popping the bubble wrap. The comic has Cueball smelling WD-40 (a penetrating oil likely to be found where machines are running), diesel fumes (likely found where trucks drop off supplies or pick up product) and what he thinks is sea air, causing him to muse that the factory is by the ocean.

In reality, the air inside most factories is much like the air anywhere else.[citation needed] This is particularly true for modern factories which are much cleaner than the popular conception of a dirty, smelly factory from early in the days of industrialization. One would be unlikely to distinctly smell WD-40 or diesel fumes standing in such a factory unless it was right after or right near they were

used. It would be even less likely to smell them when the minuscule amounts of air in the bubbles was then diluted in the larger amount of air surrounding you when they are popped. Furthermore, although the comic suggests popping the bubbles gives one a "tour" of the factory, in fact all of the air added to the bubbles would only come from air near the machine where the wrap is made. It would be even less likely to pick up smells from other parts of the factory such as diesel fumes from the loading docks, since air is not added to bubble wrap there.

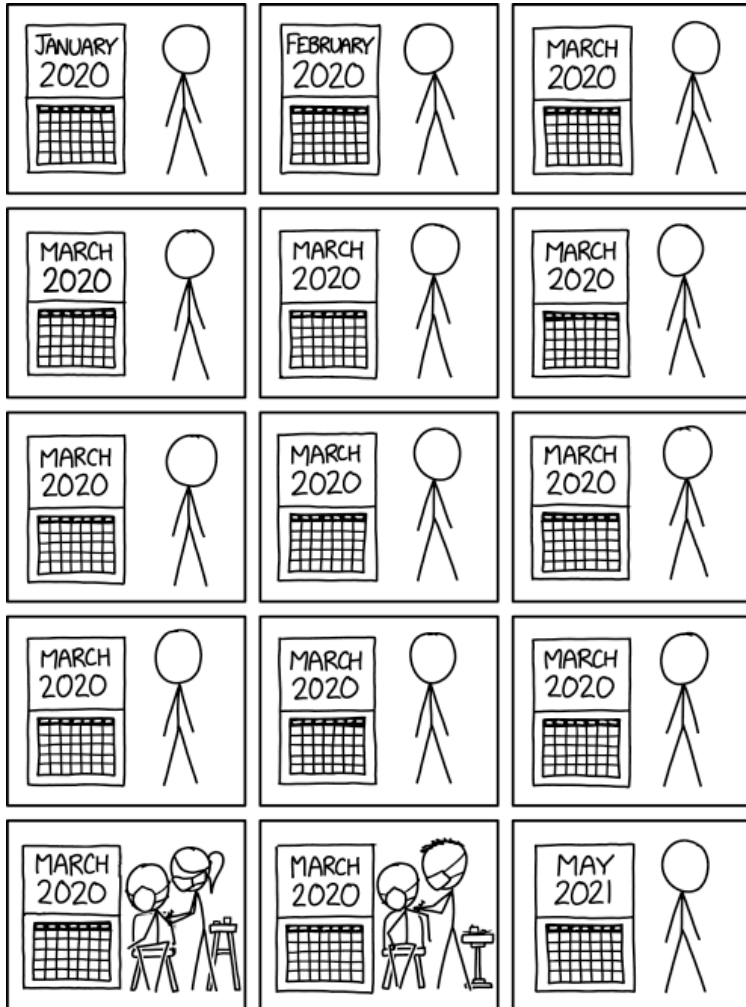
Although this scenario is unlikely given human olfactory ability, scientists with very sensitive equipment have done essentially this with ice cores. As ice is laid down in places such as the Greenland or Antarctic ice sheets, it traps small bubbles from the atmosphere at the time within it. As long as the ice remains frozen, those bubbles remain trapped and do not interact with the current atmosphere, preserving a record of the chemical composition of the air in the past. There have been many scientific expeditions to drill ice cores and then melt pieces of them in a laboratory where special equipment can analyze the ancient air as it is released to study the quantity of oxygen and CO₂ within in. The deeper the core is drilled, the farther in the past the sample.

The title text references David Attenborough, who is famous for having narrated many influential documentaries for the BBC about life on earth. He is renowned for having brought science into the homes of tens of millions. The title text humorously suggests that

Cueball thinks his "narration" about what he smells in the bubble wrap is as important and distinguished as Attenborough's award winning work.

#2459: March 2020

May 05, 2021



"I've traveled here from the year 2020 to bring you this vaccine!"

Explanation

This comic is another in a series of comics related to the COVID-19 pandemic, specifically regarding the COVID-19 vaccine.

This comic shows 15 calendars and Cueball next to them. The first three months on the calendar are January, February and March 2020. It would be expected that the months would increase in order, but the calendar month stays at March 2020 until the final panel of the comic, where it switches to May 2021, the month this comic was released, indicating that Cueball is "stuck" in March 2020 for more than a year. The COVID-19 pandemic reached the United States in March 2020 and Cueball (probably representing Randall) may feel that he has been unable to move on with life, or that time was at a standstill until he was fully vaccinated. It is plausible that Randall was past the two weeks after his final vaccination when this comic came out. He has made several comics centered around that of being fully vaccinated in the weeks up to this comic. Specifically 2450: Post Vaccine Social Scheduling and 2454: Fully Vaccinated in April.

In the penultimate 2 panels, Cueball is shown getting his two doses of the vaccine, with Ponytail and Hairy administering the vaccine. Also these two panels are in March 2020, but in reality they are most likely in March 2021 and April 2021, as there are typically 3-6 weeks between first and second dose depending on the type of vaccine. In the final panel, the calendar has switched to

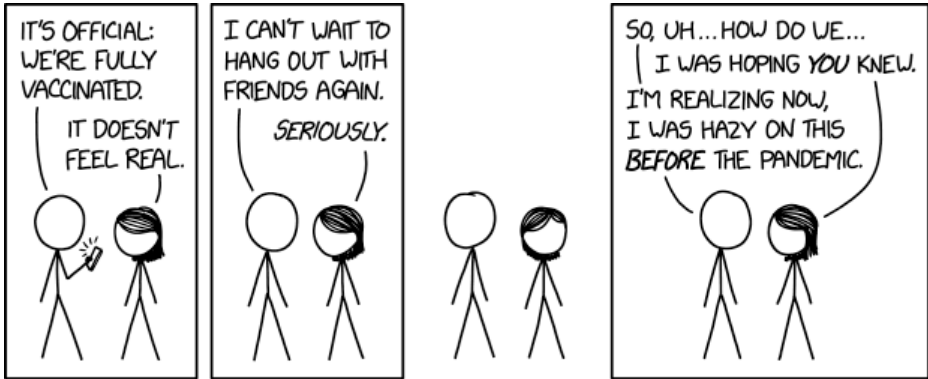
the current month, May 2021, showing that Cueball can now resume life after getting vaccinated, and most likely having passed the two weeks after final shot mark.

The title text references 630: Time Travel, another time-related comic. While it's technically true that the vaccines were brought from the year 2020, it was through the ordinary "one day per day" form of time travel illustrated in this earlier comic.

Interestingly, there are only 15 panels, so if the 'normal' months increased in sync, it would "only" be March 2021, not May 2021. This may refer to the strange distortion of time during the COVID-19 pandemic. Clearly 17 panels would have made more sense when counting months, but the point here is that time has been at a standstill the last 14 months from March 2020 to April 2021; how many panels represents those 14 month (14, 12 or 10) is not important. Using 15 panels, makes the first 3 and the last 3 stand out from the 9 in the middle, which makes sense from the flow of the comic.

#2460: Vaccinated

May 07, 2021



I built a model that combines local case rates and vaccination stats to estimate when it's reasonable to attend various types of party, but I forgot to include anything about where to find them.

Explanation

This comic is another in a series of comics related to the COVID-19 pandemic, specifically regarding the COVID-19 vaccine.

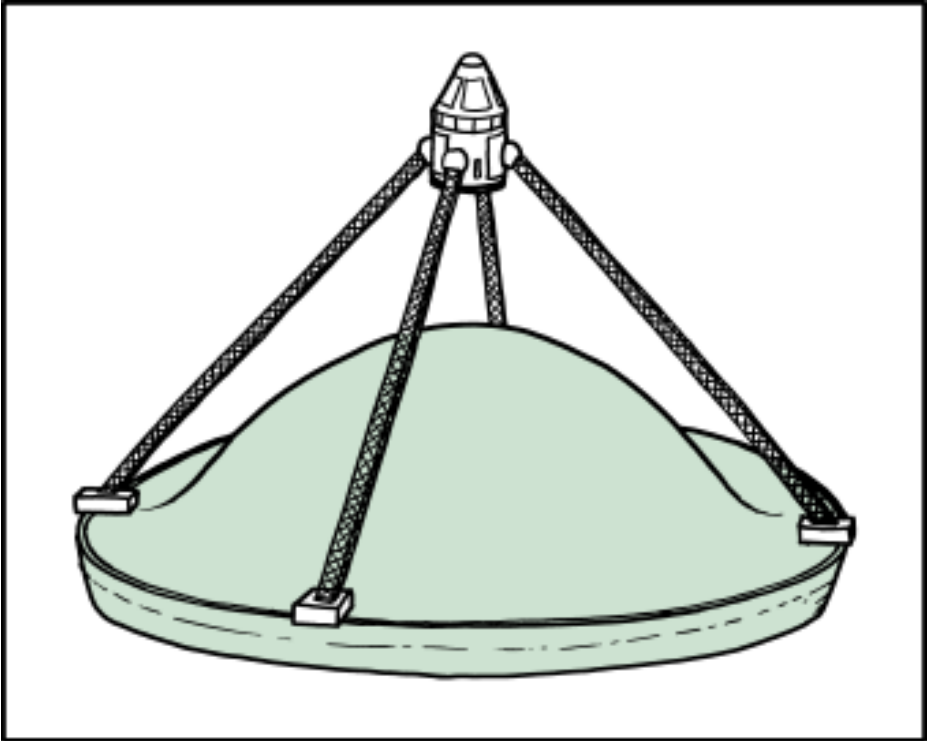
Hooray, Cueball and Megan are finally fully vaccinated! This means that they are now able to socialize within society, as they are unafraid of being infected by COVID or spreading COVID to others.

However, the punchline lies in the fact that Cueball and Megan have never been good with social interactions, and are still unsure of how to do this.

The title text continues with this theme, as Cueball (or Megan?) is good at building mathematical models to know when it is safe to attend parties (and other large gatherings), but the issue remains that they are not commonly invited to these events, or are socially awkward when attending them.

#2461: 90's Kid Space Program

May 10, 2021



THE 90's KID SPACE PROGRAM PREPARES
FOR THEIR FIRST ORBITAL LAUNCH

NASA may not want to admit it, but at this point they ARE the 90's Kid Space Program.

Explanation

The "launch system" is just one of the rubber popper toys popular in the 1990s. These toys are little rubber hemispheres, about 1" (25 mm) in diameter and 1/8" (3 mm) thick. When turned inside-out and placed on a hard surface, they will, after a short wait, snap back to their original shape, popping up into the air. The joke is that kids who grew up with these toys will think they're a great idea to propel a space ship to orbit, when in fact the toys launch at mere tens of kilometers per hour, far short of the thousands needed to reach orbital speed[citation needed]. But now kids playing with these are those that make rockets, hence the title 90's Kid Space Program (KSP).

Even if the popper-based propulsion system could generate enough acceleration to reach orbit, the abrupt impulse would likely cause serious harm to any astronauts.

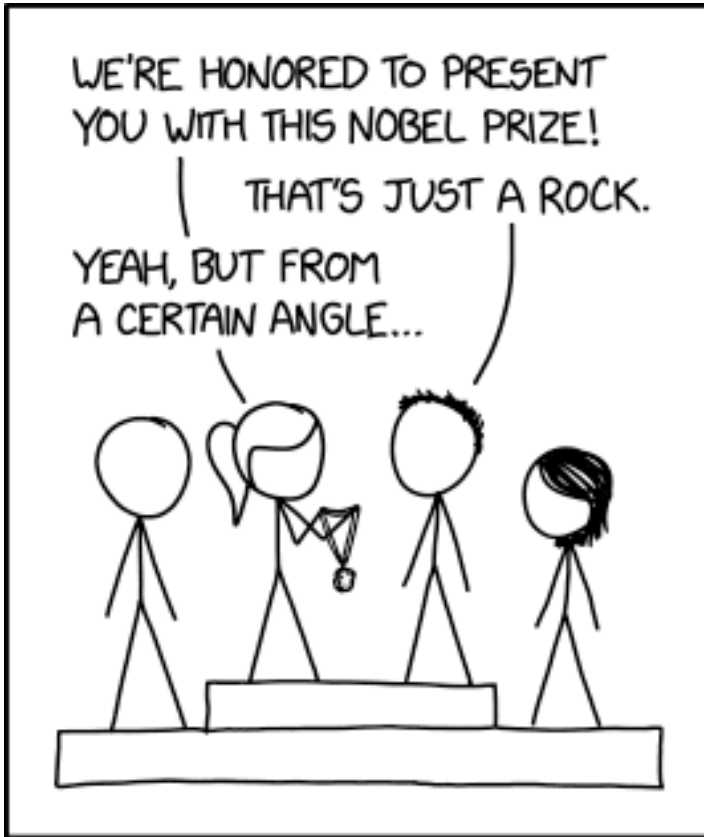
The title text implies that many working now at NASA were 90s kids. Both categories would include Randall, as he was born in 1984 and previously worked at NASA.

The title is a reference to the Kerbal Space Program (KSP) which has been a recurring theme on xkcd, and it has previously been hinted at that NASA's employees uses this program in 1244: Six Words and 2204: Ksp 2. And also that you learn more about orbital Mechanics by using KSP than from being hired by NASA in 1356:

Orbital Mechanics.

#2462: NASA Award

May 12, 2021



NASA HAS A NEW AWARD FOR PEOPLE
ON THE INTERNET WHO CLAIM TO
FIND LIFE IN THEIR MARS PHOTOS.

The key to discovering life on Mars is to find someone who built a camera and landed it on Mars. Then you just look through the pictures for plants and dogs and stuff.

Explanation

In this comic Hairy is awarded a "Nobel Prize" by NASA, represented by Ponytail handing him the award, as well as Cueball and Megan. He receives this award because he has found "life on Mars" by looking at NASA's images from their Mars missions. Hairy looks at his prize, and remarks that it is just a rock on a ribbon. To this Ponytail replies that from a certain angle... implying that if he looks hard enough the rock might look like a Nobel Prize. Just like Hairy, by looking at the pictures in the right way, found something that looked like life on Mars.

This comic jabs at poorly-supported claims of discovering alien life, particularly when instances of pareidolia are used as "evidence" of such life. Pareidolia is the tendency for perception to spuriously impose a meaningful interpretation on a nebulous visual stimulus, for example a rock that is interpreted as a face. A famous example is the Face on Mars, a 2km long hill that can be said to resemble the face of a human when viewed on low resolution images, at a specific angle and lighting conditions. At the time some people claimed this was proof of an ancient Martian civilization. Later higher resolution images showed that the face was an optical illusion.

Rocks make for poor prizes as they make for poor evidence,[citation needed] and looking from different angles is of no use for either.

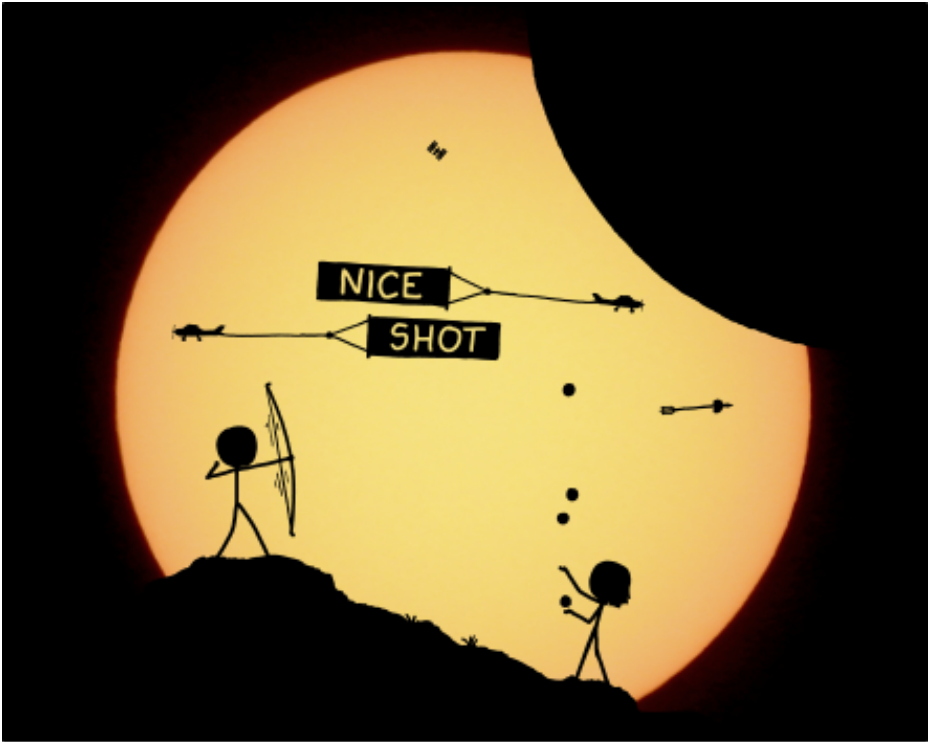
If you're actively looking for patterns in large amounts of data (especially if it's any pattern, largely undefined until it is 'found') then you are likely to dismiss all the data that does not support your preconceived ideas and seize upon the small randomnesses that you have managed to trawl though and classify as 'interesting'. This is an example of Confirmation Bias. It's possible that the featured NASA personnel specifically sifted rocks looking for one that looked like an award.

The title text explains how you find life on Mars. Just access other people's images that have been taken on Mars, and look for plants and animals. This is lampooning the simplistic notion that life on Mars would be detected by looking at photos at all. In reality, all extraterrestrial life (in this solar system at least) is almost certainly microscopic. The notion of detecting it by studying photos of the Martian surface is just as absurd as the idea of looking at the photos and expecting to see dogs and trees and other familiar macroscopic lifeforms.

Building a camera and landing it on Mars is what NASA does with their Mars rovers and other Mars missions. The camera is a small part of the entire mission, though an important part. But this is why the title text talks about landing the camera on Mars. The space probes are the cameras.

#2463: Astrophotography

May 14, 2021



OUR ASTROPHOTOGRAPHY COMMUNITY'S
ONE-UPSMANSHIP IS GETTING OUT OF HAND.

[One hill over, a competing astrophotographer does a backflip over a commercial airliner while throwing a tray of plastic space stations into the air, through which a falcon swoops to 'grab' the real one.]

Explanation

Astrophotography is the practice of taking pictures of astronomical objects. Sometimes it is specified as a hobby, as opposed to the work of professional astronomers. Astrophotographers like to take pretty pictures of all sorts of objects in the sky, but photographing the Sun is a popular subgenre within the field, especially if something is transiting in front of it. Typical things include planes, the International Space Station (ISS), and the Moon (Solar eclipses).

Whilst the Total Solar Eclipse 2017 (which previously was a recurring theme on xkcd) was visible across US, it was possible to see the ISS pass in front of the Sun during a partial part of the Eclipse (from a site that was later in the total Eclipse zone). This was photographed and filmed by Destin from Smarter Every Day and can be seen in his video *Space Station Transiting 2017 ECLIPSE*. (Go to the time of the flyby of the ISS in the video [here](#)).

Two years later he did another episode *South American Eclipse - Argentina*. In this video there was only the moon eclipsing the sun, at first, but then towards the end the sun begins to set behind the distant mountains creating a shadow scenario between Moon and mountain shadows as displayed in this comic.

This comic thus combines those two videos, which Randall must have seen, and then adds several more

layers caused by the Astrophotography community's One-Upmanship. The practice of "one-upmanship" refers to the practice of achieving something superior to what another has achieved, or "getting one up on" them. The term originated in the 1950s or earlier.

The caption claims that the photo shown in the comic is the result of a continuous string of one-upmanship among astrophotographers in a community, each striving to one-up the other.

In this comic there seems to be an abundance of things:

- The ISS can be seen transiting in the upper center. (as in this picture)
- There is an ongoing partial solar eclipse so the view of the Sun is partially obscured by the Moon in the upper right quadrant.

These two things are what Destin managed in his first video.

- The Sun is setting or rising from behind a hill while partially eclipsed.

This is what Destin managed in his second video.

- This photographer achieved a combination of those two plus several other ones-up those two videos.
- Megan is standing slightly below the peak of a hill and seems to be juggling with five balls, which are also in front of the sun. One or more of those balls might

actually be sunspots or the planets Mercury or Venus.

- Cueball is standing at the peak of the hill, shooting an arrow from a bow, one arrow has pierced what at first appears to be one of the juggling balls, but may be a Transit of Venus.

It is unclear if Megan is juggling five balls and Cueball shot one, or if Megan is juggling four balls and Cueball put the fifth ball on the arrow before shooting it.

A simultaneous Eclipse and Transit of Venus is actually expected in the future, but not until April 5, 15232 (13211 years after the publishing of this comic). That said, it would though likely be easier to make the arrow "hit" Venus than one of the juggled balls, as the planet's angular velocity is significantly lower.

- Two airplanes pulling banners with the words "nice" and "shot" (which could refer to both the archer and the photographer) are flying in opposite directions above them. (Airplane banners that are not continuous sheets are made with thin support lines spanning the openings, which explains the presence of the apparently unsupported central disc in the "O".)

The central disc in the O could also be a perfectly-aligned circular sunspot.

Taking the picture required precisely scheduling and arranging the relative positions of several of the various subjects (and photographer) to coincide with the predictable but rare conjunctions of the rest of the scene, as well as special equipment:

- All this had to be timed very very precisely as the transit of the ISS only takes a second.
- A solar filter must be used to photograph the sun without overexposing the image or even damaging equipment.
- The photograph must be taken during a partial solar eclipse. These only happen a few times per year and are only visible in part of the world.
- The photographer must be quite far away with a telephoto lens to achieve the visual scale. A nearby person appears larger than the moon. It is possible to photograph the silhouette of a person or a cityscape in front of a full moon, making the moon look comparatively larger or smaller by adjusting the distance to the closer subject, and then the lenses used by the photographer to make them both fill just the right amount of the frame.

The photographer would need to be approximately one kilometer distant if the image is a typical human scale. Both Sun and Moon have a visual angle of about 0.5 degrees. The characters are approximately $\frac{1}{5}$ the Sun's height giving a 0.1 degree visual angle. A right triangle with a height of 1.7 meters (a typical human height) spanning 0.1 degrees for the side angle, the distance would be 974 meters (3195 feet) from Cueball and Megan.

The photographer taking this image would need a high magnification 2-meter (2000mm) equivalent lens or a shorter lens with a cropped image to fill the frame as in

the comic. Long telephoto lenses like those are uncommon for most photographers, but would be available among astrophotography groups.

- The exposure time of the photograph had to be short enough to capture clear silhouettes of the ISS, the juggling balls and the arrow while these were in the air.
- The mountain had to be in a location that would happen to see the ISS passing in front of the sun at the same time as the sun was rising from behind it.
- The subjects had to achieve a moment in which four juggling balls were in the air and an arrow had pierced the point where Venus would appear, while sideways relative to the sun's light, with still near normal intensity.
- The planes also needed to be flying in the correct directions for the text of the signs to be visible, and with very precise timing for them to be in the correct positions to read "Nice" as coming before "Shot" just as the ISS passes by.
- The sky (at least between the photographer and the Sun) had to be free of clouds.

The title text describes a similarly outlandish photo attempting to one-up Cueball and Megan, done simultaneously on the next hill over, thus a place where the same ISS transit can be seen:

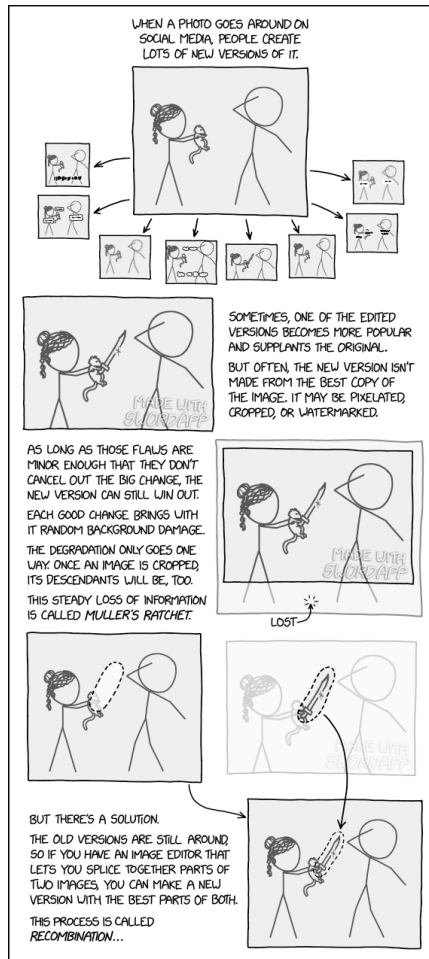
- A commercial airliner is flying in front of the Sun, thus this has to be timed with the flight plan (or it has to be

chartered), to pass there at the correct height and position, within a few seconds.

- The astrophotographer is performing a backflip such that they appear to be over the airliner.
- The astrophotographer is tossing several tiny models of the ISS from a tray, so they also appear in front of the Sun with the real one (like the juggling balls and Venus).
- A falcon is flying in front of the Sun, presumably intending to capture prey, in such a way that it appears to be snatching the real ISS out of the fakes. The falcon moves slowly compared to the ISS, so it just needs its talons to be on the line the ISS makes across the Sun, then a picture where it is close to the talons can be used. The other parts are slower than this.

#2464: Muller's Ratchet

May 17, 2021



PEOPLE USE EVOLUTIONARY METAPHORS TO EXPLAIN THE SPREAD OF INTERNET CONTENT, BUT AT THIS POINT WE HAVE SO MUCH EXPERIENCE WITH THE INTERNET THAT I FEEL LIKE IT OFTEN MAKES MORE SENSE THE OTHER WAY AROUND.

Who knew you could learn so much about sexual reproduction from looking at pictures on the internet!

Explanation

In this comic, Randall reviews a passage explaining the internet with terms associated with evolution, comparing the constant resharing and changing of popular photos to evolutionary processes, namely Muller's ratchet and recombination.

An image of Hairbun showing a cat to Cueball, who is apparently shocked, is used as an example of the subject phenomenon. This image is altered in various ways:

- A caption is added to the photo as a whole, possibly using an online "meme maker" tool. Many memes are made in this manner, such as the Office Space "that would be great" memes.
- Individual labels are placed on the participants (which include the cat). These labels may be literal, but often they are metaphorical. A common metaphorical example is the Distracted-boyfriend meme.
- This seems to be unmodified from the original, except being a bit fuzzy. This is likely a comment on how most people, due to being unfamiliar with image formats, will often pick settings when saving a picture that results in the image being compressed noticeably (usually via exporting as a JPG as opposed to a PNG).
- A caption is added at the top and bottom of the picture, again possibly by an online meme maker, and the photo cropped.
- A sword has been added to the picture, held in a

comical position by a participant (the cat) who wouldn't usually have one.[citation needed] These are typically just done as a joke. This image is also cropped and has its aspect ratio changed.

A watermark is added to this image, having been added by "SwordApp" a fictional (as of this comic's publication) app used to add the sword

- Individual labels are placed on the participants here as well.
- Individual labels are placed on the main (human) participants only. This might be used to only apply metaphorical meanings to the people and not to the object being held (the cat).

Recombination is the combination of genetic material from chromosomes, shuffling genes during meiosis. In this case, it is being compared to shuffling and recombining aspects of an edited digital image.

Sometimes, genetic mutation can create better genes - like the sword being given to the cat in the image. Other changes remove or degrade from the genetic history, without apparent detriment, just because the circumstances do not currently confer any significant advantage to it. If the 'lost' ability is perhaps useful in dealing with an infrequent environmental stress then the loss of its utility might be felt a generation or two later.

With recombination, useful novel changes can be shuffled into the population without necessarily bringing

in a less useful mutation, creating descendents with both the obvious advantages (a sword) and the previously more established resilience (the fuller frame).

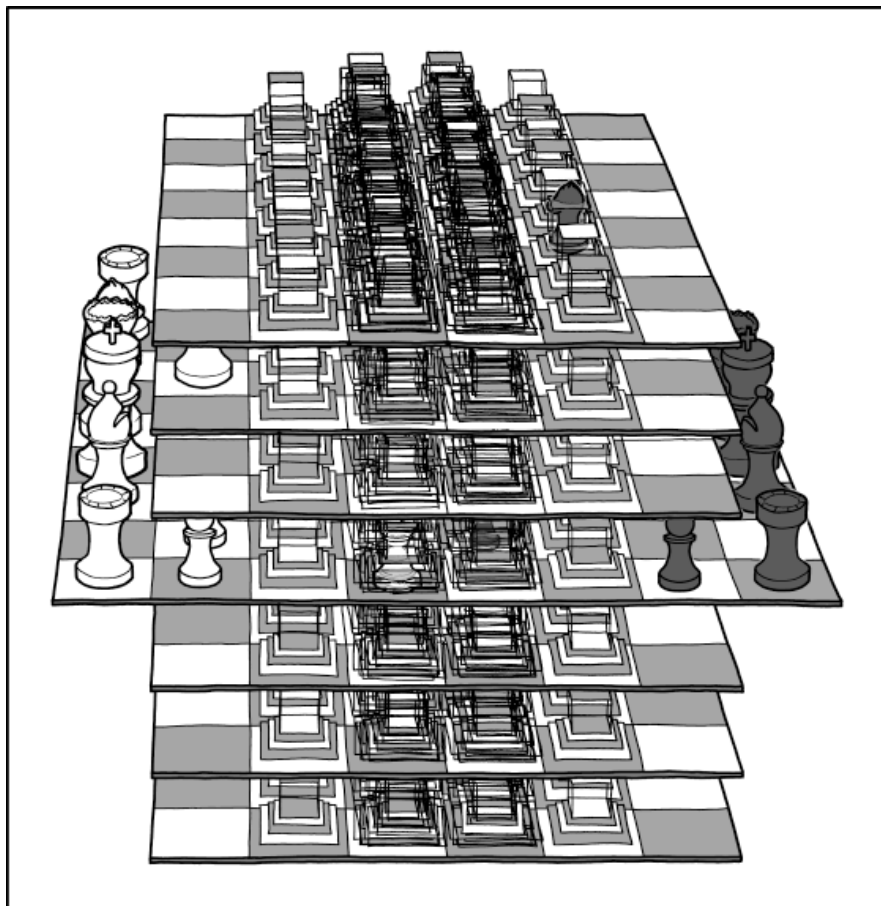
The caption in this comic jokes that while the passage is explaining the spread of Internet content using evolution, such as with the words "meme" and "viral", Randall feels that Internet image memes (like the one shown in the comic) have become so ubiquitous that it now seems more intuitive to instead explain evolution using the metaphor of images on the Internet.

The degradation of digital images has previously been explored in 1683: Digital Data.

The title text has a double meaning, referring both to the ways these particular images on the Internet illustrate these evolutionary processes (which are driven by the mechanisms of biological reproduction, including sexual reproduction) and to the amount of erotic imagery illustrating the mechanics of sexual activity one might find on the Internet.

#2465: Dimensional Chess

May 19, 2021



THE PROBLEM WITH N -DIMENSIONAL CHESS IS THAT N IS A CONSTANT ACROSS THE BOARD. IN MY NEW VARIANT, EVERY ROW HAS ONE MORE DIMENSION THAN THE ONE BEHIND IT.

In Dimensional Chess, every move is annotated '?!'.

Explanation

Being good at chess is often regarded as a sign of high intelligence. A skilled player must be able to consider possibilities several moves in advance, which can be represented as an exponentially growing tree of possibilities. The branching factor of chess, the approximate number of legal moves available at any given time, is about thirty-five, although most players (human and computer) will use heuristics to prune the trees to regard only likely or promising moves. Expanding the playing field by generalizing to three-dimensional chess (or beyond) will increase the branching factor even further, and so someone who is able to competently play three-dimensional chess could be regarded as even more intelligent than someone who can only play two-dimensional chess. Making chess into an N-dimensional game thus makes it arbitrarily more difficult, even before Randall's addition of non-uniform dimensionality of the board.

Regarding Randall's rule that "every row has one more dimension than the one behind it," it is easiest to see how this is applied with the first two rows on each end. The first row on each end is a like a row on a traditional two-dimensional chess board (albeit played with three-dimensional pieces): you can go from left to right, or forward into the next row. The second row then becomes a two-dimensional row of a three-dimensional space: you can go left to right, forward to back, and now top to bottom. Note that there are seven spaces

(represented by "shelves") from top to bottom, as opposed to the typical eight rows from left to right/front to back. This is likely to make sure there is symmetry between how many additional spaces are on top versus on the bottom (three, in this case). Moving another row would presumably add movement in some other direction to make it more complicated/interesting. This escalates until somehow the middle two rows require moving pieces in five dimensions (the middle two rows are four-dimensional rows + moving to other rows as fifth dimension), despite humans only being able to experience three spatial dimensions.[citation needed] This could potentially be accomplished via playing on a computer, such as in the game 5D Chess with Multiverse Time Travel.

There are eight squares on the first row, 56 on the second row and presumably 504 on the third and 1512 on the fourth, thus making the total number of squares 4160 rather than the 64 of a traditional chess board. The drawing shows apparently five squares (or boxes) stacked on the third row and if this is also formed symmetrically, there are four hidden out of sight. The middle rows are already quite convoluted but it seems as if Randall drew three boxes along this dimension. Due to this dimensionality increase, there is plenty of free space in the middle board, drastically changing the game dynamics such that shadowing plays very little role and that movement is very unrestricted.

The title text refers to the practice of writing down what happens throughout the game, so that it is possible to

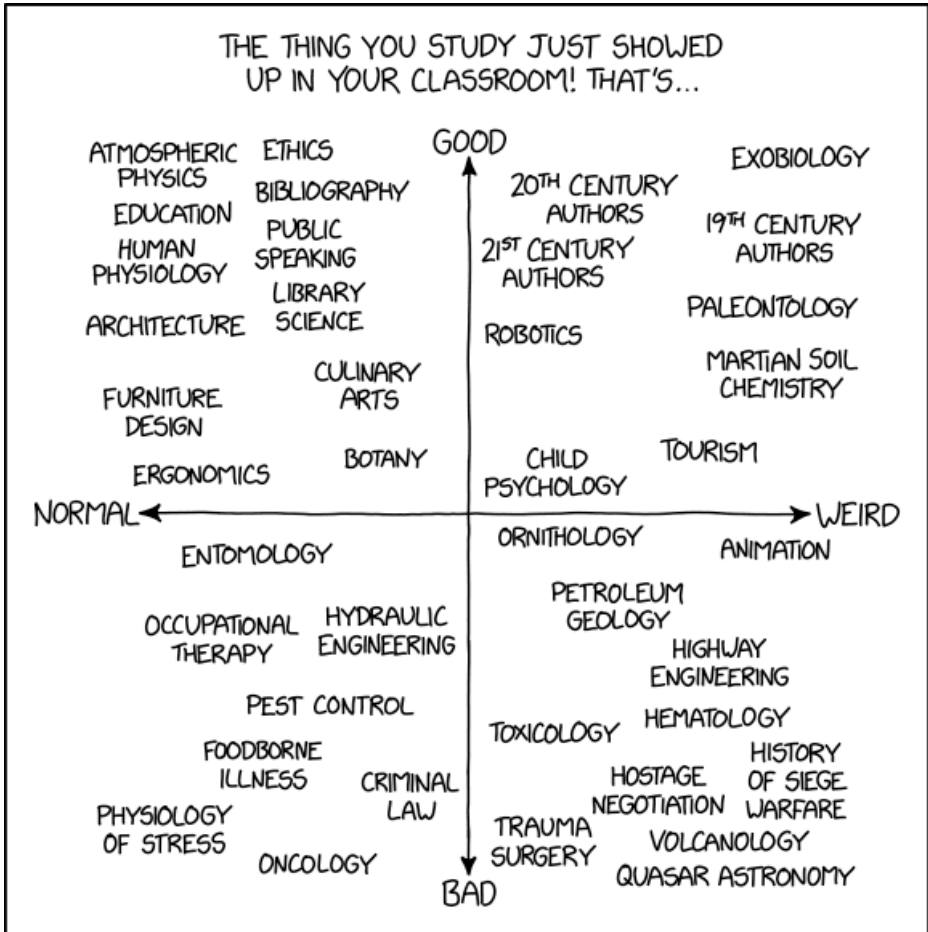
review how the game progressed later. Recording moves in this fashion is required in most tournament situations. There are several common forms of Chess notation used for this purpose, and as well as indicating the moves, players may add annotations indicating their opinions about whether a particular move was good, bad, or peculiar. According to the title text, every annotation is followed by "?!"—which indicates a questionable move, of dubious value but not obviously a blunder either. The joke is that the variable-dimensional game is so complicated that any move will answer this description.

There appears to be the normal chess pieces (so no Fairy chess pieces), but the game has already started (there are white and black pawns in one of the middle squares, and both white and black knights have moved).

Note that "in dimensional chess" may be a pun on "N-dimensional chess."

#2466: In Your Classroom

May 21, 2021



Ontology is way off to the left and geography is way off to the right.

Explanation

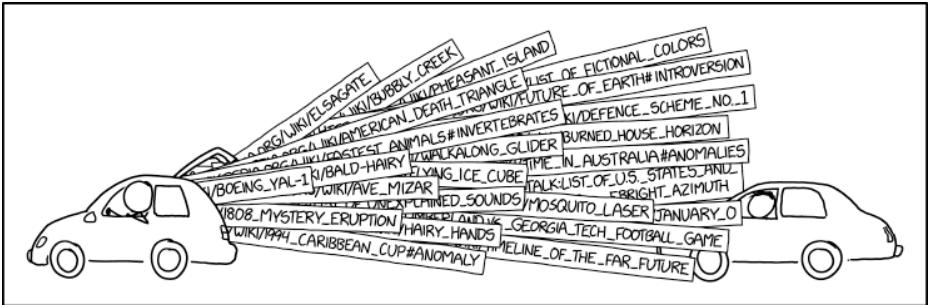
Randall has created a thought experiment and corresponding chart about school courses. The idea is, "the subject of the class appears in the classroom" and the chart compares how dangerous and how unusual that would be.

In the title text two points that are off the chart to the left and right are also mentioned. See details about all the subjects in the table below.

Note that Randall uses similar diagrams in each of 388: Fuck Grapefruit, 1242: Scary Names and 1501: Mysteries, which also contain different items. They also have extra points mentioned in the title text. In the first two comics the points are also off the chart, whereas for the last the description of the point is too long to fit on the chart. Extra info outside the chart is also used in the title text of 1785: Wifi, but this is a line graph. Extra info outside a map is also used in the title text of United States Map.

#2467: Wikipedia Caltrops

May 24, 2021



I HAVE A COLLECTION OF WIKIPEDIA LINKS TO THROW BEHIND MY CAR IF I'M EVER BEING CHASED BY SOMEONE AS EASILY DISTRACTED AS ME.

Oh no, they set up a roadblock which is just a sign with the entire 'Czech hedgehog' article printed on it.

Explanation

Cueball's car has a collection of Wikipedia links spilling out of the trunk, meant to stop Hairy who's in the following car. The idea is that by dropping a series of interesting links, one could stop someone else's movement as they take the time to go through them all, provided that they are also easily distracted. This is analogous to the caltrops mentioned in the title; caltrops are small, spiked implements that are scattered on a road to slow down someone pursuing you. Hence the title of Wikipedia Caltrops.

Wikipedia is also a website that is notorious for having many links to other pages, which may result in a "wiki walk", a dilemma for Randall that has been discussed previously in 214: The Problem with Wikipedia (and separately with TV Tropes in 609: Tab Explosion).

This strategy is similar to a weaponized version of 356: Nerd Sniping, using the high levels of focus that tend to come along with nerdy interests against someone. Munroe apparently reasons that, because these links would stop him in his tracks, they might do the same for a given target.

The Wikipedia links include:

- 1808 mystery eruption: A conjectured volcanic eruption
- 1916 Cumberland vs. Georgia Tech football game: The

most uneven college football game in history

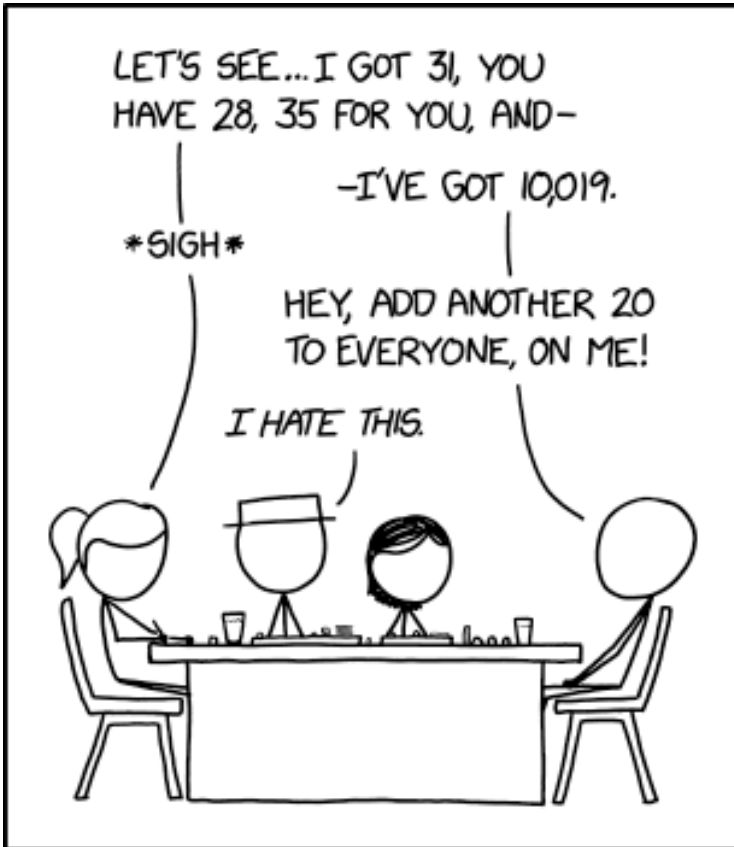
- 1994 Caribbean Cup#Anomaly: A soccer game where group stage qualification rules had unintended consequences
- American death triangle: An unsafe type of rock climbing anchor
- AVE Mizar: A 1970s flying car
- Bald-hairy: A Russian political theory about state leaders' hairstyles
- Boeing YAL-1: A laser weapon mounted on a military aircraft
- Bubbly Creek: A stretch of river in Chicago featured in The Jungle
- Burned house horizon: An area where Neolithic people burned their settlements
- Defence Scheme No. 1: A 1920s plan for Canada to attack the USA
- Elagate: A YouTube controversy involving inappropriate videos being categorised as child-friendly
- Fastest animals#Invertebrates: Very fast insects, and some squid
- Flying ice cube: An effect in molecular dynamics simulations
- Future of Earth#Introversion: A model of future continental drift in which the Atlantic closes up
- Hairy Hands: A ghost story in Dartmoor, England
- January 0: December 31st in some software programs

- List of fictional colors: Impossible colours in fiction
- List of unexplained sounds: Mostly detected by NOAA, includes the Bloop
- Talk:List of U.S. states and territories by elevation/Archive 1#Delaware - Ebright Azimuth: A user argues the highest point in Delaware isn't Ebright Azimuth, but a trailer park
- Mosquito laser: A proposed device for killing mosquitoes
- Pheasant Island: An island shared equally between France and Spain
- Time in Australia#Anomalies: Places in Australia which do not use the expected time zone
- Timeline of the far future: Scientific speculation
- Walkalong glider: A type of unpowered model aircraft

Mentioned in the title text, a "Czech hedgehog" is an anti-tank obstacle made of metal, essentially a large caltrop. It would be an effective roadblock, however a sign describing it would not impede most traffic, [citation needed] only for those distracted as easily as Randall.

#2468: Inheritance

May 26, 2021



NO ONE WANTS TO PLAY BOARD GAMES WITH ME EVER SINCE I INHERITED 4,000,000 VICTORY POINTS FROM MY GRANDFATHER.

People ask me whether I feel any moral qualms about the source of the points, but if he hadn't introduced factory farming to *Agricola*, someone else would have.

Explanation

This comic is in reference to strategy board games, which often score players on some type of point system based on a variety of possible achievements. The joke in this comic is that Cueball has a massive sum of points that were not scored in the current game but rather handed down from his grandfather. Board games do not normally include an inheritance from previous sessions, in contrast to real life where some people become wealthy by inheriting vast sums of money from ancestors. Such inheritances tend to lead to 'successes' in life for those who have done little to earn their wealth.

Cueball offers to distribute a trifling fraction of his points to the other players, teasing them, but he will still have an insurmountable advantage.[citation needed] Despite his 'generosity', no one wants to play a game that they have no chance of winning. The value of his score, 10,019, seems to indicate that he "earned" 19 points during the course of the game (less than his competitors) and then added 10,000 from his 'inheritance'.

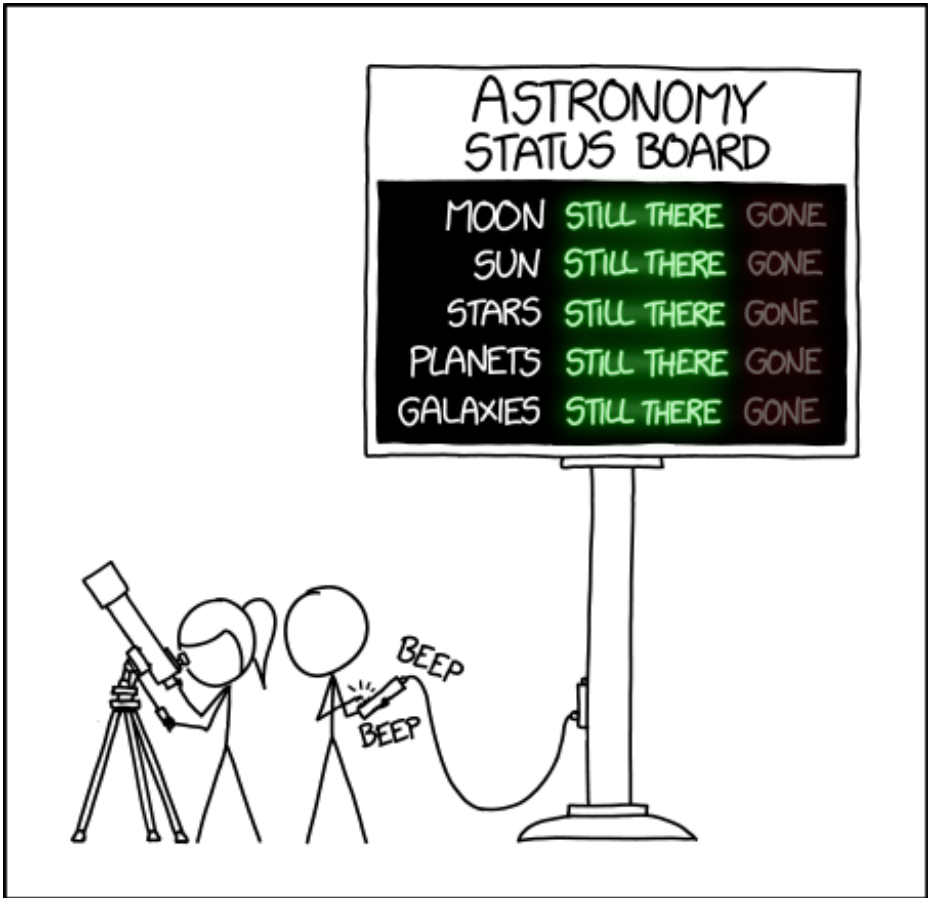
The comic may be a reference to economic simulation board games like Monopoly, which was created as a critique to capitalism; in this case, no one can win the game against people who start out with a large amount of accumulated wealth. See also the 'Small Loan of a Million Dollars' trope of a profile in which the author or subject discusses the simple tricks they used to retire early or buy a house, often involving a hurried admission of

financial assistance from a family member.

The title text asks Cueball if he has any moral qualms over the source of these points, then indicates his grandfather's fortune was made through factory farming in the farm-themed board game *Agricola*. Factory farming is a broad term for applying mass-production techniques to agriculture, treating both plants and animals as commodities to be processed as efficiently as possible. These techniques are condemned, at least in some circles, as being cruel to livestock, in addition to having serious environmental and land-use implications, among other criticisms. The implication is that Cueball's grandfather somehow managed to introduce an immoral and/or socially harmful mechanic into a board game, greatly enriching himself and his heirs. This echoes another concern about inherited wealth: that the source of the money may have been unethical, but the heirs still get to enjoy the advantages, without considering themselves accountable for the harm. Cueball brushes off this criticism with the claim that the change was inevitable, which is a common response to analogous real-life concerns. The game *Agricola* was previously mentioned in 696: Strip Games and 778: Scheduling.

#2469: Astronomy Status Board

May 28, 2021



Junior astronomers hate getting put on board update duty, but someone's gotta make sure that stuff is still up there.

Explanation

Ponytail is staring at the sky through a telescope while Cueball is operating a checklist, visible on a large screen on what looks like a large billboard.

Since they are junior astronomers, they appear to have been tasked with simply verifying whether normal celestial objects are still present in the sky, such as the Sun and the Moon. Only large objects that are clear in the sky (at least at night for those not the Sun). Although all of these objects will eventually disappear it is not expected to happen within the life of the status board. [citation needed]

This is likely a reference to the many "status boards" for online services (example, another example, a different example, a funnier example). The joke is that it would be funny if there was a status board to check that all the celestial bodies are still there, and that with our modern culture few people are looking directly at the real sky, even though anyone with a telescope and an unobstructed view could just look at the sky to verify for themselves without referencing such a status board. This is compounded by the fact that the listed celestial bodies have existed for billions of years, and are expected to last for billions more, leading one to wonder why astronomers would bother checking and rechecking just to see if they're "still there" with any sort of regularity.

This comic may also be an oblique reference to the study

of the projected future of celestial objects given our current understanding of physics. At various points in the future the objects on the billboard may become unobservable from Earth. The Moon is gradually receding from Earth, and when the Sun enters its red giant phase the Moon might be broken up. Eventually the Sun itself will run out of usable fuel and will go dark as will other stars. Moreover, if current theories of dark energy and universal expansion hold, the acceleration of the universe could push galaxies beyond the "Hubble Horizon", meaning they would no longer be observable. Matter itself could even cease to exist under some hypothetical scenarios, such as proton decay or the Big Rip. The joke of the comic here would be that all these scenarios are only possible in the unimaginably far future (exception: False Vacuum Decay) and do not need constant monitoring by astronomers.

#2470: Next Slide Please

May 31, 2021

DID YOU KNOW?

TRANSCRIPTS OF FAMOUS QUOTES OFTEN
LEAVE OUT THE SLIDESHOW INSTRUCTIONS.
HERE'S HOW THESE LINES ACTUALLY SOUNDED:

"GIVE ME LIBERTY OR GIVE ME—NEXT SLIDE, PLEASE—DEATH!"

"MR. GORBACHEV, TEAR DOWN—NEXT SLIDE, PLEASE—THIS WALL."

"IT WAS THE BEST OF TIMES—NEXT SLIDE,
PLEASE—IT WAS THE WORST OF TIMES."

"WE HAVE NOTHING TO FEAR BUT—
NEXT SLIDE, PLEASE—FEAR ITSELF."

"TO BE, OR—NEXT SLIDE, PLEASE—
NOT TO BE, THAT IS THE QUESTION."

"SHALL I COMPARE THEE TO A SUMMER'S DAY? THOU
ART—NEXT SLIDE, PLEASE—MORE LOVELY, AND—NEXT
SLIDE, PLEASE—MORE TEMPERATE."



"WE SHALL FIGHT—NEXT SLIDE,
PLEASE—ON THE BEACHES,
WE SHALL FIGHT ON—NEXT SLIDE,
PLEASE—THE LANDING GROUNDS.."

"READ MY LIPS—NEXT SLIDE,
PLEASE—NO NEW TAXES."

"THAT'S ONE SMALL STEP FOR
MAN—NEXT SLIDE, PLEASE—
ONE GIANT LEAP FOR MANKIND."

"FRIENDS, ROMANS, COUNTRYMEN, LEND ME YOUR EARS! NEXT
SLIDE, PLEASE. I COME TO BURY CAESAR, NOT TO PRAISE HIM!"

"IT IS A TRUTH UNIVERSALLY ACKNOWLEDGED, THAT A SINGLE
MAN IN POSSESSION OF—NEXT SLIDE, PLEASE—A GOOD FORTUNE,
MUST BE IN WANT OF—NEXT SLIDE, PLEASE—A WIFE."

"VENI, VIDI—VELIM, PICTURA PROXIMA—VICI!"

"I have nothing to offer but blood--next slide,
please--toil--next slide, please--tears, and--next slide,
please--sweat."

Explanation

This comic presumes that many famous quotes are actually excerpts from slideshow presentations, and the text they were reading was split across multiple slides. Splitting sentences across multiple slides can often be a useful tool if there are images accompanying it, which could explain the specific placement of many of "next slide, please" comments. For example, in the quote "It was the best of times, it was the worst of times," one can imagine the speaker starting with a slide that showed the prosperity of some people then, in the middle of the sentence, switching to a slide of many people's destitution. When using images this way, it is often better for timing purposes to have control of your own slides. However, Randall claims that, in these speeches, the person making the speech wasn't controlling their slide presentation, so they had to ask the operator to go to the next slide. A common way to ask this is to say "next slide, please", but these requests would have been edited out of the historical transcripts. The comic imagines the places where the slide breaks might have been, and inserts that request.

Most of these quotes are drawn from speeches, which could conceivably have been accompanied by slides or other stage directions ("pause for laughter"), but the list is quite ridiculous as it includes works of literature, where the reader is the one who turns pages as necessary, and speeches from periods of history, such as the American Revolution and Caesar's *Veni, vidi, vici* speech, which

predated slide projectors[citation needed]. Even in the quotations that take place in an era with slide projectors, every single one is an instance where the speaker was, quite famously, recorded live — said recordings would show there were in fact no edits, and certainly not any instructions for a slide projector operator. See details in the table below, including the quote in the title text.

The phrase "Next slide, please" is perhaps in a sweet-spot of utility and performance. A rehearsed presentation, with speaker and 'slide handler' working with a tight script, could probably do without off-stage prompting at all, or the better lecturers with an oft-repeated talk could set it all on timings knowing they can keep the changes synchronised with their speech, or vice-versa. But when a cue is necessary, an unambiguous signal should be used, and an audible 'clicker' (or a small and briefly flashed light) has been used historically, especially with pre-electronic slide-shows where the slide-operator at the back of an auditorium needed to clearly discern the intent of the person at the lectern.

In the United Kingdom, England's Chief Medical Officer caused some amusement on social media with the constant use of the phrase in coronavirus presentations, culminating in the availability of many mugs and cards with his image and this slogan on, and a campaign to purchase an automatic clicker for him instead.

Table of quotes[edit]

#2471: Hippo Attacks

June 02, 2021



It's cool how, when there's a number lots of people are curious about, but which isn't easy to measure, some random guess will get cited everywhere and become the universally quoted value. Unrelatedly, did you know there

are 850 trillion waves in the ocean?

Explanation

The first part of this comic deals with unreliable sources on the internet. Neither "viral posts" nor "random listicles" are usually very reliable sources of information. They rarely cite their sources,[citation needed] and they are often published without much fact-checking, as published volume and impressive-sounding numbers are far more important for ad-revenue than actual facts.

The viral post appears to be this Facebook post. The relevant source is unknown (and may very well be made up, since the source is ClickHole, a satirical website formerly owned by The Onion). There are a number of listicles Cueball may be referring to, but they all appear to be citing the Bill & Melinda Gates Foundation, however, even they do not seem to provide source for the number of fatalities caused by hippopotamus.

The quip turns on a pun between "hippo" and "HIPAA". The Health Insurance Portability and Accountability Act (HIPAA, pronounced HIP-uh) is an American healthcare law enacted in 1996. One of the most commonly cited provisions from HIPAA is the HIPAA Privacy Rule, which regulates the use and disclosure of protected health information.

In this comic, Cueball and Megan are discussing the number of hippopotamus attacks, which is unverified. Megan proposes an alternative explanation as to why this particular number is hard to come by: it would be

violating the patients' privacy to create statistics of a very specific and unusual cause of death. The punchline comes with the pun on "hippo violation" ("HIPAA violation").

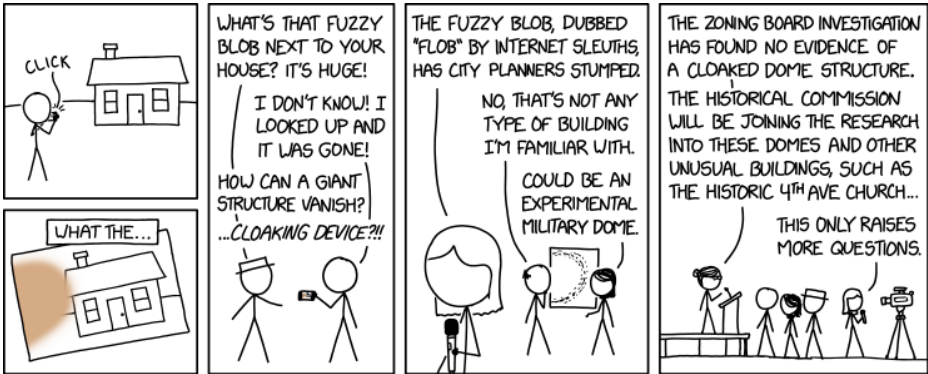
The title text amplifies the criticism of listicles. They sometimes provide factoids with regards to ill-defined, hard-to-measure numbers, and these factoids might end up in common circulation between such articles. One extreme example would be the number of waves in the ocean. Some problems with this definition would be:

- In which ocean/oceans?
- What is the smallest ripple that counts as a wave?
- When does one count two interacting waves as separate, and when does one count them as one?
- Are counted waves limited to water waves, or can EM waves be considered?
- Should sub-surface waves be evaluated, too?
- How deep is the ocean, how high is the sky?

With different replies to these questions, wildly different answers could be reached. But, counting every body of water on the planet, 850 trillion waves works out as around 2.354 (unique) waves per square meter.

#2472: Fuzzy Blob

June 04, 2021



If there's no dome, how do you explain the irregularities the board discovered in the zoning permits issued in that area!?

Explanation

Cueball is taking a picture of his house, but sees a large fuzzy blob on the side of the picture. This blob comes from Cueball making the mistake of putting one of his fingers partially in front of the lens. This is a common enough occurrence with smartphones or compact cameras that an ordinary user should immediately be able to identify the problem; however, the comic derives humor from having no one in the comic come to this conclusion, and accordingly taking it very seriously as a perplexing mystery.

Likely, this comic stems from the resurgent talk of Unidentified Flying Objects (UFO) now dubbed "Unidentified Aerial Phenomena" (UAP). The topic regained popularity after the Department of Defense (DoD), recently confirmed the authenticity of 3 videos taken by US Naval personnel. It has been much discussed in mainstream news, not just among extraterrestrial enthusiasts or conspiracy theorists, some of whom have created QAnon spin-off theories.

Randall has previously expressed skepticism about claims of witnesses who claim to have seen unproven phenomena (including 'flying saucers', as well as supernatural events and cryptozoological specimens) based on the simple reality enough people carry cameras that they would be constantly captured in photos and videos. (See 1235: Settled).

In this strip Randall appears cases where phenomena have been caught on film, but are generally unclear and ambiguous. He appears to be suggesting that there are generally simpler explanations for what we see in the videos than objects of alien origin. Examples in the past have turned out to be things such as birds, dirt on camera lenses and lights being reflected off glass windows or bodies of water. The fact that many people seem uninterested in the more mundane and likely explanations and assume these videos are proof of alien crafts is mocked here.

It's worth noting that Randall is a strong enthusiast for space exploration, and has expressed certainty that intelligent life exists elsewhere in the galaxy. This strip is likely not intended to mock belief that other intelligences exist (notably, the conspiracy theorists in the strip assume the "flob" is man-made, not alien) but instead to make fun of excessive credulity, and point out that any definitive conclusion of aliens is overhyped.

In the final panel, Hairbun mentions further inquiry into "the historic 4th Ave Church". This is a reference to a blurry spot on the Google Maps street view image of the Fourth Avenue United Methodist Church (turn to the back of the Street View, facing the church). This is similar to the spot in the comic, and disappears in other views of the church, so is likely caused by a camera or software problem.

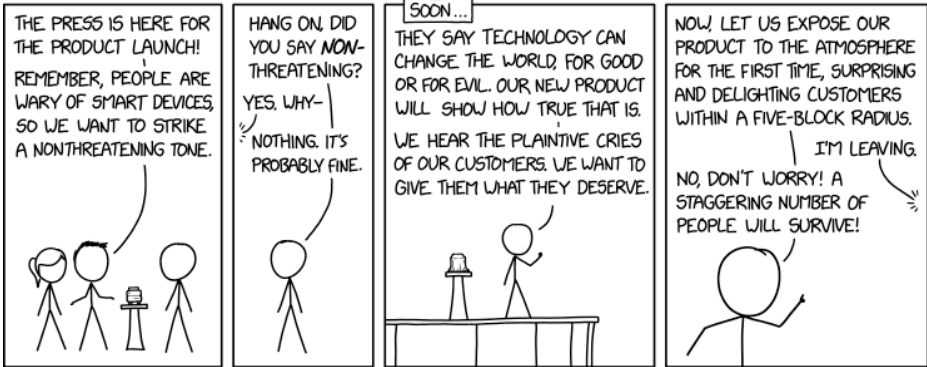
The tendency to make unwarranted connections to unrelated but synchronous 'evidence' is shown in the title

text. Investigation of this phenomena has brought to light 'irregularities' in the local zoning permits. Such irregularities are extremely common in most bureaucracies, and may be the result of mundane corruption, incompetence, honest mistakes in a complex system, or the result of complexities that make consistent documents difficult or impossible. To connect such irregularities to an identified image does not follow logically, as both are pretty normal occurrences. However, conspiracy theories make similar leaps all the time, insisting that some case of corruption, bad decision by a government official, or developing social problem is proof of a conspiracy, rather than a very normal government problem.

An alternate intention of the word 'irregularities' might be due to the necessarily zig-zaggy nature of defining a 'circular' zone footprint by drawing best-fit boundary lines only along streets, within any established grid-based system of city 'blocks'. The interpretation of why any zone is a complex and crinkly shape, rather than a strictly utilitarian rectangle, may not be so obvious from an overview that does not take into account geological or political restrictions such as the curve of a watercourse in a valley or a mandate against hi-rise buildings within a certain radius of a monument.

#2473: Product Launch

June 07, 2021



"Okay, that was weird, but the product reveal was normal. I think the danger is pas--" "One more thing." "Oh no."

Explanation

Three people are discussing the upcoming public announcement of their company's new product, apparently an electronic device shown on the pedestal between them. Tech companies will often debut a major new project with a presentation, inviting reporters and other influential figures to see the new product for the first time, and have its features demonstrated. These presentations are intended to generate both awareness and positive publicity, and so are styled to be attention-getting, with a good deal of showmanship and dramatic descriptions.

Hairy mentions that smart devices can make people uncomfortable. Common reasons include:

- It is impossible for consumers to know what the device is really doing (since it is a "black box" with inaccessible software).
- The device could stop working in the future due to poor quality or software problems;
- The device could be used to spy on its owner or others, including ones who did not consent to this by purchasing the device.
- The device could represent a security or even safety risk by allowing hackers or other groups access to the network or any systems that the device controls.
- The device could significantly alter the life of the user via digital addiction.

To allay these concerns, the device should be presented as non-threatening. Cueball asks to confirm the non, implying that this was not clear to him before. In fact, it even appears he thought he was being asked to put together a threatening presentation, but does not explain.

Later, Cueball presents the device on-stage, with statements that are clearly styled to carry double meanings which tend to sound foreboding, even if the product being presented is benign or beneficial.

- He confirms that the product can "change the world for good or evil" (specifying that evil is an option suggests that this product has potential for evil).
- The "plaintive cries of [the company's] customers" sounds worrying, while such cries might be demands for a new product, the same phrase would be used if people were distressed by the product.
- The company wants to "give [customers] what they deserve" doesn't specify whether he believes they deserve reward or punishment.
- Instead of being merely uncovered, the product is being exposed to the atmosphere (implying a chemical or physical reaction) and is to affect customers within five city blocks (nearly 1 km). That kind of specific radius of impact is usually associated with a disaster, such as an explosion or chemical attack.
- When someone in the audience decides to leave in the middle of the presentation, Cueball reassures them that a "staggering" large number of people will survive.

Bringing up the number of people who will survive implies that there will be fatalities, which is not an expected feature of most product launches.[citation needed]

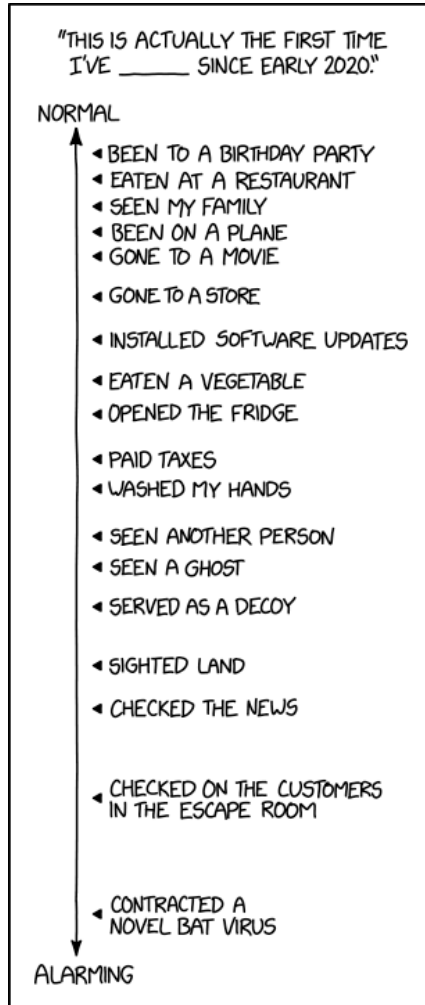
In the title text, someone is saying that the actual reveal was uneventful. Cueball interrupts, implying that there is one last feature to demonstrate. This is likely a reference to Steve Jobs, who was famous for presenting such product launches as CEO of Apple Inc. Jobs would often appear to finish his presentation, then say "one more thing," before surprising the audience with another unexpected feature. In this case, however, the presentation is so foreboding that people are relieved when it seems to end without danger. When Cueball has more to demonstrate, they assume that the real threat is still coming.

Besides the main joke of a product that is likely so unsafe as to be illegal, the comic could also be poking fun at the desire of tech companies to make their products sound important, which can undermine the message of benign safety.

This comic was released on the day of Apple's 2021 WWDC (Worldwide Developer Conference) keynote, at which the company traditionally announces new features and products.

#2474: First Time Since Early 2020

June 09, 2021



Gotten the Ferris wheel operator's attention

Explanation

This is yet another comic part of the series of comics on the COVID-19 pandemic.

This comic is a chart that orders things based on the level of alarm that would occur if it were revealed that someone had not done a given thing since early 2020. Many of the items, but not all, are linked to new constraints due to the pandemic.

The title text serves as another chart point, though it isn't given where it is on the chart.

Going to a birthday party was a normal task before the pandemic, and it's normal to say you haven't gone to one since early 2020.

Eating at a restaurant was also common before governments instated lockdowns, but during the lockdowns many restaurants had to limit their service to delivery and take-out.

Seeing your family was fairly common before the governments instated lockdowns. However, there were emergency visits during the lockdown period.

Governments around the world cancelled commercial flights during the pandemic. However, businessmen like Bill Gates used private jets during the pandemic.

Many cinema halls around the world closed due to the

pandemic. Several movies were instead released directly to TV via OTT platforms.

Although some stores were closed during the lockdown period, others were open for essential commodities. Therefore, going to a store for the first time since early 2020 is little strange.

Regularly installing software updates is recommended, mainly for security reasons. However, many people don't follow these recommendations (mostly by fear of software inconsistency or instability), although a delay of more than one year is quite long. Mentioning software updates is weird, because it is not directly related to the COVID pandemic. On the contrary, since many people spent much more time at home and worked at home, it was all the more important to keep software up to date, especially due to zero-day exploits.

Since vegetables are essential to a healthy diet, not eating a single vegetable in a whole year is not recommended.[citation needed] Anxiety due to the pandemic and disruption of social relations may have caused people to consume more junk food than usual.

This is quite weird, since most people use their refrigerators to store fresh food. Maybe some people became anorexic because of anxiety due to the pandemic or stopped consuming fresh food and relied more on junk food. Moreover, most food products will alter or rot if stored in a fridge for more than one year, and become dangerous to eat.[citation needed]

Although some people, depending on where they live and their income, may not pay taxes in an immediately obvious way, there are some taxes, such as VAT in many countries and sales tax in the United States or Canada, which almost everyone would pay in the natural course of everyday life, though may not be 'obvious' in the paying, or even be extracted at source (withheld from payroll) in the simpler cases. (Randall lives in Massachusetts, which does not have a VAT, but does have a 6.25% sales tax.) It is therefore strange that someone could have gone a year without paying any taxes, implying they made almost no monetary transactions in the period, nor are made (directly) responsible for any residential or property-owning taxations that might otherwise be payable to one or other layer of government.

If the statement refers specifically to filing income taxes (which is often the case when people refer to "taxes", because the paperwork and large sums of money transferred at once makes the income tax highly noticeable and memorable), it might describe someone who filed a tax return for 2019 early in 2020 and then waited until later in 2021 to file a return for 2020.

One of the main pieces of advice during the pandemic was to wash one's hands, frequently. Even in normal circumstances, washing hands is a good idea to remain hygienic,[citation needed] and not do so for a year would be disgusting to most people, and a good way of catching diseases.

Like paying taxes, it is very common to wash one's hands inadvertently as part of another activity, so someone who actually has not washed their hands since early 2020 likely also never bathed or showered.

Despite the restrictions, most people will have seen another person during the pandemic, virtually or otherwise.

The fact that the speaker apparently has seen a ghost, both now and presumably before early 2020 (else they would simply say it was the 'first time' they saw a ghost) is unusual.[citation needed]

In addition, it is possible that someone who tells you that they haven't seen a ghost recently is implying that you are a ghost they currently see. If true, this would be quite alarming to most people.

Similar to the previous point, this is not a normal activity, so the specificity is unusual.

Most people live on land,[citation needed] so sighting land should not be unusual, even during a pandemic. The fact that someone has gone over a year without sighting land suggests they have been lost at sea for the duration. There are several reported cases of ships' crews refused permission to disembark, due to local restrictions and/or because their scheduled relief were unable to embark, but the unluckily held-on persons forced to remain beyond their originally planned obligations should never have been left permanently beyond any

tantalizingly unreachable view of the shore.

Taken more literally, it could simply mean that the person remained indoors and did not look outside, or that the person was temporarily blind.

If someone has not checked the news since early 2020, they will likely be in for a shock upon checking. Noting that this could possibly (if increasingly absurdly) still apply to someone like Ponytail (as portrayed in strip 2396: Wonder Woman 1984).

The implication is that the customers in question have been trapped in the escape room since early 2020. Most escape rooms are not equipped to support a person for that length of time, so unless the customers actually escaped, they would likely not have survived.[citation needed]

As a 'novel bat virus' is what kicked off the whole pandemic, contracting another one may send the whole world into a new pandemic, which is certainly alarming.[citation needed]

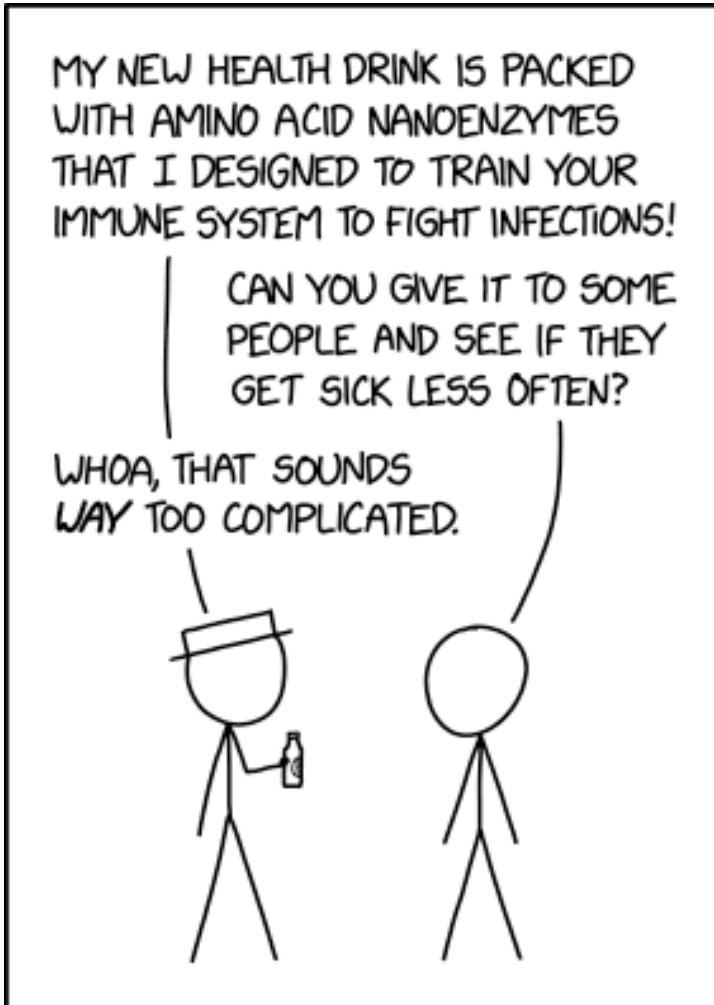
It seems that the speaker has been stuck in a Ferris wheel for a year. It is unclear how they may have survived, unless the speaker is a certain xkcd character.

Alternately, it would be perfectly normal that the speaker has not been at an amusement park with a working Ferris wheel since early 2020 - but it would be unusual to focus on interacting with the operator versus enjoying the attraction.

Several science fiction stories include wheel-like prisons where people stay for years, but generally they are underground and horizontal rather than in the air and vertical like Ferris wheels are.

#2475: Health Drink

June 11, 2021



You'd need to keep track of so many people! Would you use, like, Excel or something? Far too fancy for a simple country nanoenzyme developer like me.

Explanation

This comic pokes fun at health fads, alternative medicine, pseudoscience and the like. It points out that many such products will go out of their way to market themselves as legitimate and cutting-edge by using impressive-sounding scientific terms, yet fail to perform even the most basic part of actual science: running a randomized controlled trial to determine results. When Cueball points this out, White Hat reacts as though this process is unreasonably complicated, which clearly demonstrates that his product is either nonsensical or an active scam (or both).

Enzymes are proteins that catalyze chemical reactions. For example, certain proteins aid digestion by breaking down large molecules. Nanoenzymes are synthetic materials that perform similar functions to ordinary enzymes. While enzymes are, indeed, necessary to healthy functioning of the body, adding more enzymes is typically not helpful for a healthy person. In cases where someone has a deficiency in specific enzymes, diagnosing such a system and designing a treatment would be a complex medical process, not something that could likely be delivered through a commercial drink. Amino acids are the chemicals that make up proteins, and therefore all natural enzymes are made from amino acids. Using such redundant but technical-sounding terms is a common practice in pseudoscience, as they hope to impress and bewilder laypeople by presenting themselves as scientifically skilled.

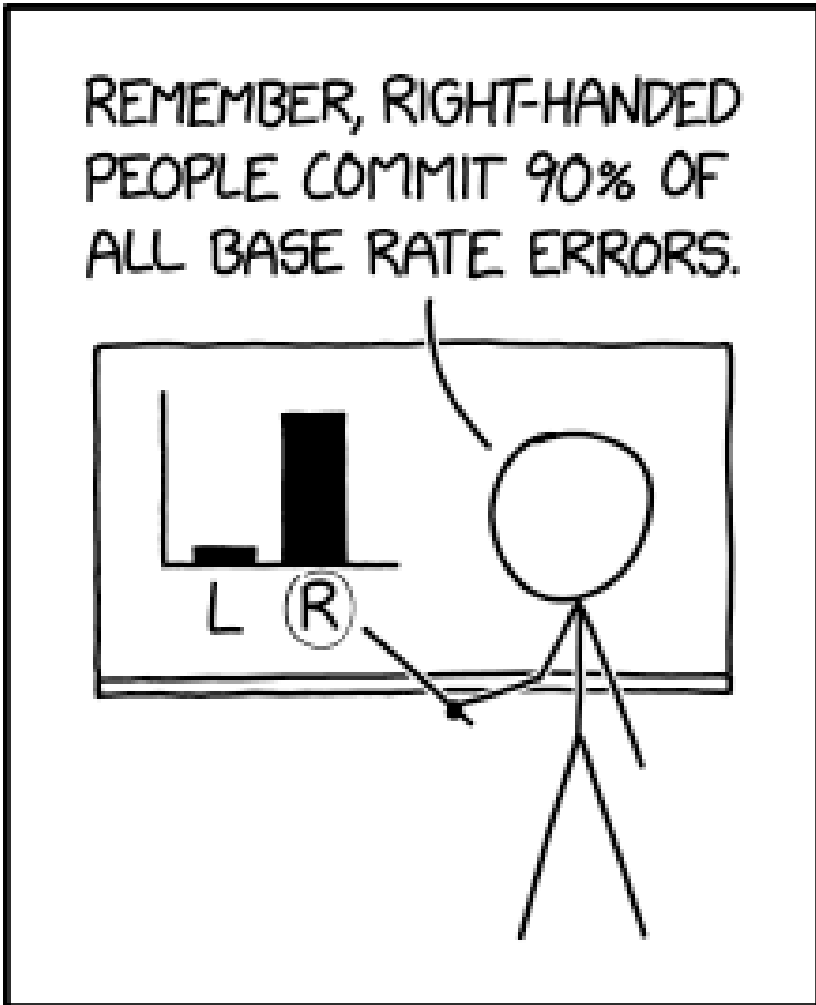
Cueball responds to this by asking if White Hat had given the drink to people to see if they got sick less often. While this is clearly very simplified, it is a good basic description of the scientific method. If the product is claimed to "fight infections", then one would need to compare groups of people who do and do not use the product, and determine whether there's a significant difference in how well they resist or recover from infections. A scientifically rigorous process would involve creating a set of criteria, recruiting subjects, randomly assigning them to control groups versus test groups, administering the product (preferably using placebos for control and a double-blind procedure), and tracking the health of each group. And, of course, keeping good records and analyzing the data properly would be critical to forming any conclusions.

White Hat's response to this suggestion implies that he's completely unfamiliar with even the concept of such a study, commenting only that it "sounds way too complicated." The title text shows him speculating as to how one would keep track of such data, and he suggests using "like, Excel or something." Microsoft Excel is a popular spreadsheet application which is commonly used to store data, but is not designed as a database, and wouldn't be appropriate for a rigorous study. Since Excel is commonly used by the general public, claim that such rudimentary data storage is "far too fancy" for him reinforces his total lack of technical knowledge. He then calls himself a "simple, country nanoenzyme developer", which highlights the conflict between presenting himself

as highly versed in cutting-edge science and not understanding the basics of how science works. All of which implies that his technical descriptions are actually nonsense, designed to fool the credulous.

#2476: Base Rate

June 14, 2021



Sure, you can talk about per-capita adjustment, but if you want to solve the problem, it's obvious that this is the group you need to focus on.

Explanation

The "base rate" is a type of base probability, which a statistical probability can be based on. The base rate fallacy is a type of error in which people are presented with the rate at which something occurs throughout an entire population along with more specific information about a subset of that population, and tend to ignore the whole-population information in favor of the specific information.

In this case, the joke is that 90% of people are right-handed, so if there is no connection between handedness and making base rate errors, then 90% of these errors would be made by right handers. Thus while Cueball's claim that right-handers commit 90% of base-rate errors is technically true, taking that as reason to believe that "making base-rate errors" is somehow specially associated with right-handed-ness -- as would be implied by an intervention effort specific to right-handed-people -- is itself a base-rate error.

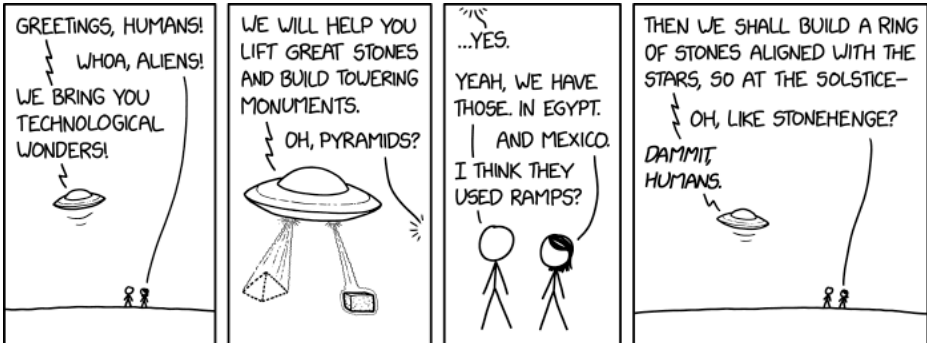
Cueball may be holding the pointer in his right hand, suggesting he might be right-handed (as 90% of stick figures are).[citation needed] Since Cueball has no facial features it is impossible to tell if he faces the audience, or looking at his graph. However, it seems most likely that he is looking at his audience while delivering the take home message and thus points at the graph behind him. Thus he likely belongs to the 90% that makes 90% of the base-rate errors, one of those he is just committing.

In the title text, Cueball dismisses the idea of adjusting his graph to account for the difference in numbers of left-handed versus right-handed members of the population. He suggests focusing efforts on the right-handed majority to resolve that 90% of base rate errors. This is a somewhat common counterargument to statistical arguments of this stripe (often as justification for racial profiling, for example); it fails because if the target group is not in fact somehow special with regard to the issue at hand, there is generally "nothing to fix" and no special approach to discover that cannot be just as easily applied to the population of the whole.

Something similar occurs in 1138: Heatmap, where Cueball makes inferences simply based on a population map of the US, instead of statistical evidence.

#2477: Alien Visitors

June 16, 2021



Stay right there, we'll be back in a minute. We've just gotta brainstorm some new wonders. Have you all figured out gears yet? Yes? Crap.

Explanation

This is the first comic in a new series, followed in the next comic by 2478: Alien Visitors 2.

This strip satirizes the ancient astronauts hypothesis: that aliens were involved in building the pyramids and Stonehenge. This concept, popular in some circles, is based on the assumption that earlier civilizations lacked the technology to build such large structures. There are also geometric or other scientific properties to these structures, which some people assume that humans of that era would have been incapable of creating. Erich von Däniken, a Swiss author, is one of the foremost proponents of "ancient astronauts." Some say that such pseudoscience is inherently racist, as it assumes, without any proof, that other civilizations were unable to build their monuments without foreign help, although others disagree since most races and nationalities have one or another of these monuments with similar claims.

In the comic, aliens arrive with the intention of building such monuments with their highly advanced technology, including some sort of tractor beam to lift the heavy stones and another beam that can depict a pyramid. They are shocked to hear from Cueball that humans accomplished the same thing thousands of years earlier with such simple tools as ramps, and even in more than one location on Earth (Pyramids in Egypt and Mexico). Thus they proceed to suggest a stone circle to predict the solstice, but before they can finish this sentence Megan

says this is like Stonehenge.

The joke of the strip is that, if aliens were interested in building such structures on earth, they'd be just as likely to show up today as thousands of years ago. And if they offered to build pyramids today, humans would be very unimpressed, as we've had the technology to do so for quite some time. The notion that an advanced, spacefaring species would come all the way to Earth (or whatever other planets they visit) to build relatively simple stone structures seems dubious, when put that way.

Alternately, the aliens may have visited Earth before in the past and impressed the humans of the time with their advanced technology of pyramids and stone circles, leading them to expect the same technology to impress the humans again in the present day. This is somewhat plausible: Stonehenge is estimated to have been built around 3100BC, while the pyramids were built 500-1000 years later. Assuming both structures were indeed built by aliens in the past, the visitors would have returned to the Earth to find agricultural civilizations almost identical to the ones they encountered centuries prior. The aliens could have then been led to believe that human technology, if almost entirely unchanged in the 500 years since they last visited, would not have advanced significantly in a few thousand years. Indeed, the aliens were mostly correct in this assessment: technological advancement progressed at a crawl until the scientific revolution marked the emergence of modern science only a relatively short 600 years ago. From this perspective,

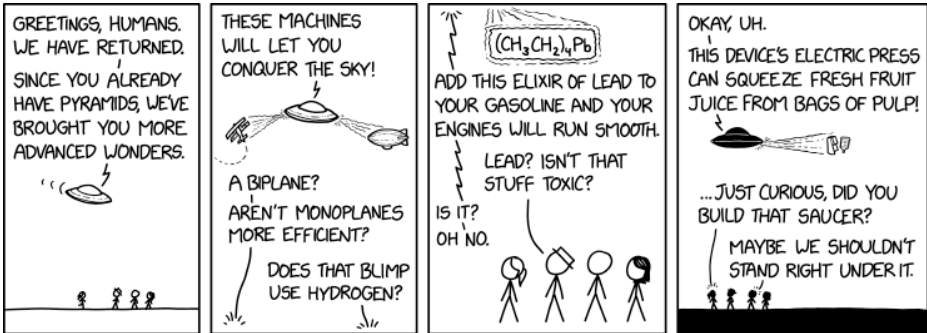
the aliens would seem to be correct in their assumption that human technology would not significantly improve such that they could not impress humanity with their technological wonders. Unfortunately, the aliens have been caught off-guard by the exponential nature of technological advancement, in that advanced civilizations have the resources to advance even more rapidly.

The aliens' reaction is frustration as they cannot teach us anything new; evidently, it does not occur to them to share their technologies for antigravity and interstellar travel (which, having come to Earth in floating spaceships, they clearly possess).

In the title text they have regrouped and would now present another wonder - gears. This is very likely a reference to the Antikythera mechanism, an artifact dating from the 2nd century BC which used a complex, geared calculating system to predict the movement of stars and planets. As with the aforementioned structures, some fringe groups theorize that such mechanisms were beyond human technology at the time, and therefore must have been given by aliens. Once again, such technology is not impressive to humans at this point, as complex, geared mechanisms are now commonplace in most human societies. Indeed, quite a bit of intricate mechanical gearing and timing has been obsoleted by electronics.

#2478: Alien Visitors 2

June 18, 2021



"Although fresh juice **DOES** sound--" **"NO!** For humanity to survive we must learn from the mistakes of the past."

Explanation

This is the second comic in a series, following the previous comic 2477: Alien Visitors.

The aliens now return to show us even more "advanced" inventions. As with the previous strip, the only innovations they offer are not only things that humans know how to build, but things we figured out some time ago, and are now obsolete. As with the pyramids and Stonehenge, these inventions might have been impressive in their time, but now offer nothing to humanity.

Biplanes are planes with two sets of wings, which provide more of the necessary lift at slow speed than a contemporaneous monoplane, but develop increased drag and aerodynamic and air-frame issues as higher air-speeds became possible/necessary. Biplanes have been obsolete for most purposes since the 1930s, though they remain in use for agriculture and aerial sports.

A blimp is a lighter than air aircraft with no internal structure. These aircraft were traditionally filled with hydrogen gas to provide the needed buoyancy, due to the lower density of hydrogen and a US monopoly on helium limiting availability for the German blimp manufacturer. Hydrogen is highly flammable and thus presents a safety issue: however, its use has gradually increased, considering that it is far cheaper than helium. The famous Hindenburg disaster is widely seen as a reason hydrogen airships are unlikely to be widely

accepted. However, it is still disputed whether the hydrogen or the coating of the airframe caused the fire. Blimps are still used today, but only rarely, in niche applications, such as for advertising or for aerial photography/videography. Modern airships generally use helium as a lifting gas, which is more expensive, but non-flammable.

Tetraethyllead ((CH₃ CH₂)₄Pb) is a chemical added to gasoline (mostly from the 1920s to the 1990s — although some countries still use it to this day) to prevent engine knocking. Lead is toxic and bio-accumulative, and there's substantial evidence that its use in gasoline caused widespread lead exposure, impacting public health on a huge scale. The aliens seem surprised to learn of these toxic effects, and their concern implies that they may be using leaded gasoline themselves, but it's unclear whether they might think that their biology may be vulnerable to lead as well or whether they never considered that biologies alien to theirs would be.

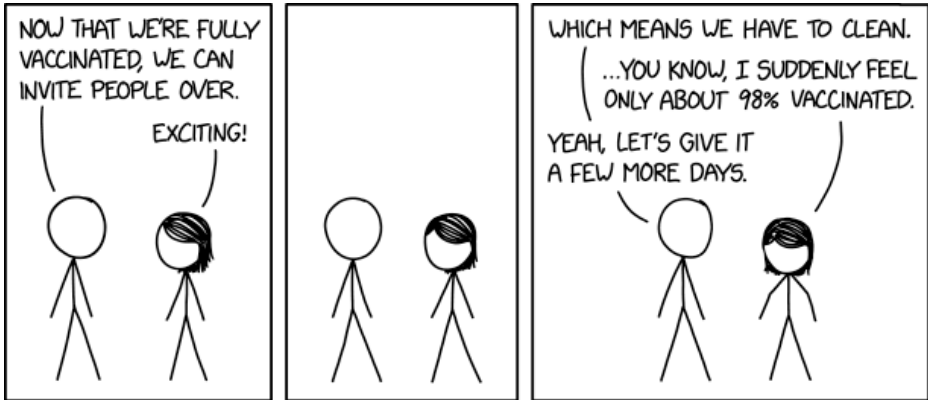
The final invention appears to be a reference to Juicero, a defunct and short-lived brand of juicer, which has become iconic of the absurdity of modern technology investment. The company produced a high-tech, internet-connected juicer which sold for \$700, and only worked on the company's proprietary branded single-serving bags of pulped fruit, which were available by subscription for \$5-\$7 per serving. The company raised over \$100 million in startup capital, but quickly went out of business because most consumers considered the expensive product to be nearly useless, coupled with a

rather damning video by Bloomberg demonstrating said packets could easily be squeezed by hand. The title text singles this invention out, calling it one of the "mistakes of the past".

After the latest showing of unimpressive "inventions", the humans start questioning how "advanced" the aliens really are. It's traditionally assumed that a species capable of interstellar travel would have a host of other advanced technologies, which is inconsistent with the unimpressive and not only obsolete, but also fatally-flawed inventions they're offering to humanity. The humans on the ground ask whether they actually built their own flying saucer. They also consider the wisdom of standing directly under the saucer, implying that, if the aliens did build it, it's likely to be unreliable, and may be at risk of crashing (though perhaps a bit ironically, most of the obsolete inventions were nonetheless reliable: biplanes and Tetraethyllead both work as advertised despite their downsides, and the Juicero was commonly slammed for being needlessly over-engineered).

#2479: Houseguests

June 21, 2021



You can come on in, we're all fully vaccinated. Except the spare room off the living room. Don't go in there, we're not fully vaccinated in there.

Explanation

This comic is another entry in a series of comics related to the COVID-19 pandemic, specifically regarding the COVID-19 vaccine.

With COVID-19 vaccines under distribution, more and more people are becoming fully vaccinated. Cueball and Megan have apparently become part of that group, and Cueball notes that with the vaccine in their systems, they can once again start hosting people at their house — the various local and national rules maintained to mitigate infections now allowing indoors association in such circumstances for many individuals. Megan concurs, indicating they have been looking forward to having their friends over.

After a beat panel, Cueball notes that if they intend to host people, they need to clean the house. Megan promptly backtracks on her eagerness to have people over, implying that her reluctance to complete this task (possibly a rather onerous one, if they have been neglecting housework during the pandemic) may outweigh her desire to socialize. Megan claims she only feels 98% vaccinated, and thus is not completely ready for houseguests; Cueball agrees that they need to wait a few more days before they are 100% vaccinated/ready for guests.

The earlier vaccination-related comic 2460: Vaccinated depicted Cueball and Megan as not very skilled at social

interactions, so it's possible they may not have many "people" to invite over anyway, or may be awkward with those they do invite over.

The title text continues the theme of "vaccination status = houseguest readiness" and assumes that this is an association of one state with the other that is commutative - that is, reversible, with either one implying the other.

In the title text, it appears Cueball and Megan have cleaned most of their house in preparation for having guests, with the evident exception of the spare room next to the living room, which is perhaps being used to store junk from the other rooms. Thus they pretend that in that room they are not fully vaccinated, as if their vaccination status is dynamically influenced by their location in their home rather than, for instance, by the memory of their adaptive immune system.

#2480: No, The Other One

June 23, 2021



Key West, Virginia is not to be confused with Key, West Virginia.

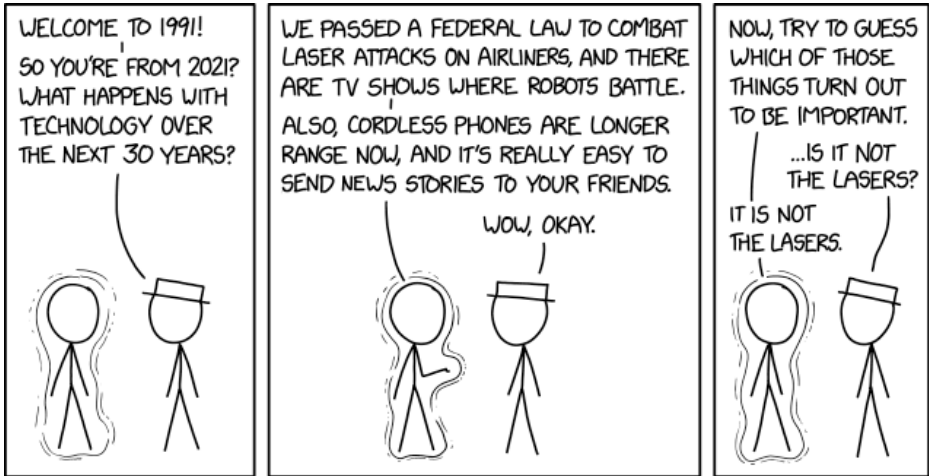
Explanation

This is a map of the United States, showing cities or towns with the same name as other more famous places. For example, the map has a dot for a relatively unknown place called Los Angeles, located in Texas, not to be confused with the very well known Los Angeles that is in California. Few place names are unique, and there may be many places with the same name. Multiple American towns have been named after the same British town, famous person, or geographic feature. However, names can become associated with specific places on a national level, where the best-known example is usually the biggest or otherwise the most significant. The name of this comic indicates the contextualization required to specify one of the less-famous exemplars of a given name. Someone might say they are from "Los Angeles" and would have to say "no, the other one" since the listener would assume they are from Los Angeles, California.

The title text references Key, West Virginia and Key West, Virginia, two places that, when spoken aloud, are only distinguishable by the pause (comma) location. Neither are to be confused with Key West, Florida, which is a location well-known nationally.

#2481: 1991 and 2021

June 25, 2021



"Oh, and our computers all have cameras now, which is nice during the pandemic lockdowns." "The **WHAT**."

Explanation

This comic shows a Cueball from 2021 who is once again discussing the future's technology with White Hat, this time in 1991 instead of 2010. White Hat is awed by the advances in technology, but is not expecting that the law combating laser attacks on passenger aircraft is not the most important thing mentioned.

"Laser attacks on airliners" sounds dramatic and important, and White Hat probably thinks that laser weapons have been developed and used to attack aircraft. Given that "a [US] federal law" has been passed to combat such attacks, White Hat may be envisioning a future where US citizens have access to laser guns, and some reckless individuals have been firing them at airplanes. (If it were some other group like terrorists or foreign militaries, a federal law would be unlikely to dissuade them.)

In reality, the "lasers" in question are low-powered laser pointers, which some people aim at passenger airliners as a (dangerous) prank. When the beam hits the airplane, it cannot damage the plane itself, much less shoot it from the sky;[citation needed] it can, however, blind the pilot, which poses a threat to them and their passengers. A law (18 USC §39A) was thus passed in 2012 to criminalize this.

The robot fighting TV shows mentioned include BattleBots, Robot Wars and MegaBots, the earliest of

which started in 1998. In them, machines armed with a variety of weapons fight in an arena. These are not technically robots or drones in the traditional sense of operating autonomously; for the most part, they are either remote controlled, or are piloted by humans and have only rudimentary on-board computer systems. They are certainly not controlled by AI. Also, while these shows have been popular enough to return to the air after periods of hiatus, they are not nearly as popular as sports involving humans.

In this comic, "cordless phone" may be meant literally, meaning any wireless phone without a cord. That's distinct from common parlance where "cordless phone" is distinct from a cellular phone, and is a wireless extension of a landline (typically of limited range, i.e. within a home and perhaps its immediate outside area). It seems likely that Cueball was using a term he believed a 1991 citizen would more easily relate to. Although cell phones had been in use for over a decade by 1991, they were most commonly depicted as a foible of a stereotypical "businessman", typically accompanied by displays of distraction, classism and self-importance. The term "cell phone" was at that time frequently used to refer to older analog cellular networks, with many mobile users proud of their new CDMA or GSM "digital" phones, as distinct from true "cellular" systems which have been deprecated since that time (this distinction has since disappeared from common usage). A more general term used in modern parlance, such as "mobile phone" or "wireless phone" may have been less recognizable to the

average person in 1991. Describing a cell phone as "a cordless phone [where you can] send news stories to your friends" would be a reasonable way of describing a cell phone to a person of that era.

Additionally, cellular phones today do not have much longer range than cellular phones of 1991 (in fact most have less range, due to their lower transmission power and use of higher frequencies, as well as indirectly due to increasing crowding on most wireless frequencies). Cordless phones reliant on a land-line may exhibit somewhat longer range than they did in 1991, due to improvements in digital error correction and audio compression. Although the effective range of a single transmission at a given power and frequency would otherwise be reduced by interference from the proliferation of other wireless devices outside functional range and/or operating independently. Satellite phones also offer more terrestrial range than cellular or cordless landline phones, however their functional range has not greatly increased since 1991 either (being already sufficient to reach a satellite within line-of-sight above). A possible explanation for a perceived "longer range" is that cellular phone towers are much more omnipresent than in 1991, granting cellular devices much greater functional area even though their functional range from one tower is typically less than in 1991.

Sharing on social media has distorted what news stories people encounter. Instead of a curated selection of important[citation needed] news fact-checked by a newspaper or tv/radio broadcast from a large corporate

media conglomerate, we see only what people similar to us found interesting.

By most reasonable measures, the most important technologies on the list could be seen as the rise of mobile phones and the ability to easily share news stories (aside of course, from any perceived advent of high-powered laser weapons or televised robotic warfare). The first of these, mobile phone usage (and smartphones in particular) has led to a dramatic change in how people communicate, with a large amount of communication now remote, which was not as convenient in the 1990s (requiring, for example, setting up roaming at the carrier's office before taking the phone to another city) and impossible for most people a few decades prior: Low frequency wireless for personal communication was relatively uncommon in the early '90s and remains so today. Sharing of news stories person-to-person is partly blamed for the spread of fake news; misinformation has become more and more politically, legally and socially significant in the past few years. While wireless communication has certainly had enormous and wide-ranging effects, the factuality of the data communicated is arguably of greater importance than the means of its communication. The joke is that the impact of a technology on society isn't really about how exciting or dangerous it might look at first glance.

The title text horrifies '90s White Hat, as it not only refers to a pandemic serious enough to induce lockdowns, but mentions it casually, in reference to the existence of computer webcams. COVID-19 is already a

hugely impactful deadly disease, but by mentioning it without details, it leaves White Hat to guess as to the details. Cueball doesn't specify whether there have been one or more pandemics (the plural use of 'lockdowns' could be taken to imply that there were more than one), or how serious they were, how long-lasting or how many lives were lost to them. In consequence, White Hat could easily be assuming a dystopian future even worse than what really happened.

#2482: Indoor Socializing

June 28, 2021



The problem with learning about biology is that everyone you meet is it.

Explanation

Cueball is meeting White Hat, who is probably not in the same household. White Hat asks how Cueball is, which is normal small talk, but Cueball responds by expressing his anxiety that they're inhaling one another's "gross lung air". Cueball then repeats a common joke regarding how impossible it is to connect with people when our conversation norms discourage honest communication, switching to a more socially acceptable "fine".

"Gross" here may be a pun on the term gross anatomy (i.e. anatomy at the macroscopic level) and "gross" as a synonym for "disgusting."

A recurring theme in xkcd is characters expressing an uncomfortable awareness of realities that most people tend to ignore, particularly for experts in a particular field (examples include 2057: Internal Monologues, 913: Core, 203: Hallucinations, and 1839: Doctor Visit). In this strip, likely as a result of being primed by awareness of the COVID-19 pandemic, Cueball finds it difficult to be in the same building with other people without being aware of the fact that they're breathing the same air, meaning that particles of biological material are being freely exchanged. In an earlier era, such concerns might have been dismissed as being extreme, but the pandemic has demonstrated that there's very real reason to be concerned. Even if everyone involved is vaccinated, that doesn't entirely remove the risk, nor does it protect

against other diseases, which can spread in similar ways.

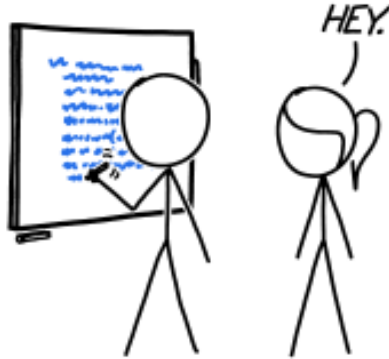
The title text reinforces the idea that knowing more about any subject increases the likelihood that you'll become disturbed by some constant and basic reality of life. In this case, studying biology tends to be disturbing, since the field involves in depth knowledge of our own bodies, as well as all other organisms we encounter, and which makes one uncomfortably aware of all the risks and flaws basic to being alive.

Normally, inhaling unfamiliar biological organisms from the bodies of others is one way the immune system learns its environment, to prepare for possible diseases like seasonal colds. With the advent of common distant travel, culture has adapted to the onslaught of new organisms people are exposed to, giving us strong senses of hygiene to protect our health beyond the adaption of our immune systems. Diverse cultures of hygiene have evolved deadly superbacteria, produced sets of people with very good hygiene and very weak immune systems, as well as saving millions of lives, providing for treatments like safe open surgery and normalizing novel piercings. Often learning of the realities of the pervasiveness of micro-organisms and the details of biology can clash with one's culture of hygiene.

#2483: Linked List Interview Problem

June 30, 2021

```
define traverseLinkedList(headPointer):  
    myID = "Kenny Mc Skully"  
    authToken = "Kenny Mc Skully"  
    museumAddress = "1111 Mc Skully St."  
    client = mailRestClient(myID, authToken)  
    client.messages.send(to=museumAddress,  
        subj="Item donation?", body="Thought you  
        might be interested: "+str(headPointer))  
    return
```



CODING INTERVIEW TIP: INTERVIEWERS GET REALLY MAD WHEN YOU TRY TO DONATE THEIR LINKED LISTS TO A TECHNOLOGY MUSEUM.

I'd traverse it myself, but it's singly linked, so I'm worried that I won't be able to find my way back to 2021.

Explanation

This is another one of Randall's Tips, this time a coding interview tip.

In computer programming, a linked list is a type of data structure that stores data throughout memory accompanied with memory addresses of the next, and potentially previous data point, establishing a relative ordering for a collection of data. Several common software engineering interview questions involve manipulating or otherwise interacting with linked lists. Possibly because programmers in the current day rarely work with linked lists directly, Randall suggests that such structures belong in a "technology museum," and thinks it would be more beneficial to mankind to email the list to such a museum rather than perform any useful work with it.

A linked list is a way to store sequential data in computer memory. Each piece of data is stored with a pointer to the next piece. This makes it very easy to add new data in the middle, since only one existing pointer must change to point to the new data. The drawback of a naive implementation can be that finding data may require following the entire chain. Technical programming interviewers like to see if applicants are familiar with the structure and the computational complexity concept itself.

Linked lists are, historically, one of the two main data

structures that represent sequential data, along with arrays. Unlike arrays, they have the theoretical advantage of $O(1)$ insertions and deletions thanks to not needing to reallocate the entire structure, but have $O(n)$ random access (see comparisons). However, modern processors' cache structure favors data that are located next to each other, pre-fetching the adjacent items, and modern processors can perform bulk memory moves, making resize operations faster. Finally, using linked lists usually implies dynamic allocation of each list member as opposed to reserving memory for a bunch of items in a bulk and then using that memory once an item has to be added. Memory allocation tends to be slow on modern systems and adds overhead for managing the information, which byte is allocated for what item, which can be significant, particularly for smaller data items; many small allocations also tend to fragment memory, which can lead to it being wasted and unavailable to the app later, particularly in long-running processes such as web servers. These properties tend to make linked lists poorly suited for most system programming applications in which a programmer might write algorithms to manipulate data structures, instead of using existing libraries.

Modern programming languages usually provide abstractions (often named "array," "vector" or "list") which interact with the sequential data at the memory level, providing access to this data while using arrays, linked lists, hybrids of the aforementioned technologies, or other approaches, and the programmer doesn't

necessarily need to care one way or another. Additionally the time a `malloc()` and a `free()` take, as well of cache considerations may make linked lists way slower than arrays or vectors, very much depending upon how either compiler or interpreter converts the user's code/script into actual machine implementation (in some cases, it's possible that the way it is ultimately handled is identical, though in others it may be possible for either/both of them to be run less than optimally compared to the best usage case). Knowing the underlying concepts is still useful, however, when creating fast running code which scales well to large data, avoiding (e.g.) traversing the list over and over again, or performing particularly inefficient operations.

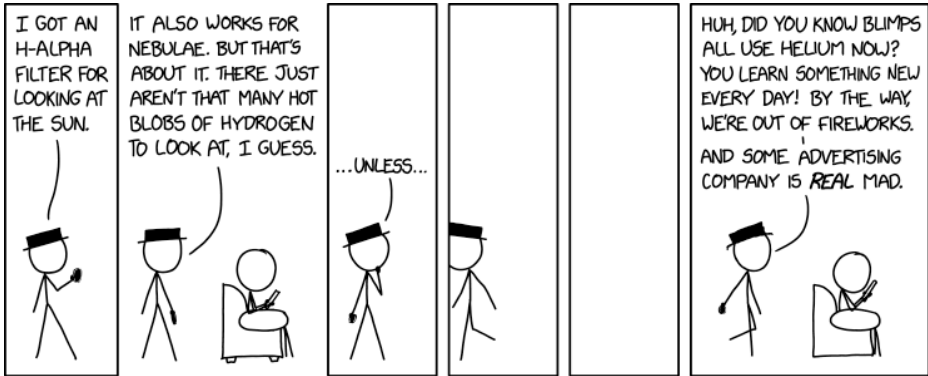
Cueball's code implements a routine whose name implies that it does a mundane task, specifically traversing a linked list, but in fact emails the contents of the list to a technology museum. This could reveal private data that might be stored in a linked list, such as bank account numbers, medical information, passwords, etc., and would thus be a terrible idea. This is why interviewers - presumably job interviewers - would "get really mad".

In the title text, a singly linked list contains pointers to traverse the list in only one direction; namely, from the head to the end. By contrast, each element in a doubly linked list contains pointers to both the "next" and "previous" elements, enabling traversal in either direction. Randall continues the implication that such lists are obsolete by implying that traversing such a list would be akin to time travel. Without the "previous

element" pointers, Randall is concerned he would not be able to reverse the time travel, as he could not traverse the list in the reverse direction.

#2484: H-alpha

July 02, 2021



"All the companies whose blimps I shot fireworks at are mad, but MetLife is especially miffed because I dressed up as the Red Baron."

Explanation

Black Hat has acquired an H-alpha filter. This is a special kind of optical filter used for scientific observations of the Sun's chromosphere. It is different from an ordinary solar filter, which is used to protect one's eyes or camera, as looking at the Sun bare-eyed will do damage to one's eyes. A camera using an ordinary (not H-alpha) solar filter was seen in 1828: ISS Solar Transit, and the consequences of not using such a filter were explored in 2227: Transit of Mercury.

Black Hat points out that the filter can also be used to look at nebulae, but doesn't see much further use for it; since the filter only transmits a very narrow bandwidth of light, one generated by hot hydrogen, it is not useful for looking at much else. This gives him an idea, and he leaves.

WARNING!!! A deep sky nebula H-alpha filter has a wider bandwidth than a solar H-alpha filter and WILL hurt the eyes if used to observe the sun!

Upon returning, his hat looks damaged. He casually shares with Cueball three seemingly unrelated observations which suggest what he was up to in the meantime: that most modern blimps use helium to keep them aloft, that their household is out of fireworks, and that an advertising company (or several, going by the title text) is upset. Early in the 20th century, most airships such as blimps and zeppelins used hydrogen as the lifting

gas. There were several incidents in which this gas ignited while the ships were in flight, resulting in spectacular and catastrophic fireballs, most famously the Hindenburg disaster. Taken together, the implication is that Black Hat tried to set someone's advertising blimp alight using fireworks; so he could use his H-alpha filter to look at the burning hydrogen.

In modern times, one of the most well-known uses of airships is blimps for advertising, as they are an unusual and hence attention-getting sight in the sky, offer a large surface area that can be used to show a slogan or logo, and can stay aloft for a long time at comparatively little cost. Modern blimps almost exclusively use helium as a lifting gas. While helium is significantly more expensive than hydrogen (and a non-renewable resource), it has similar weight and therefore similar lifting power to hydrogen, but is not flammable. (In fact, as a noble gas, helium is totally non-reactive under normal conditions). Any attempt to cause a hydrogen fireball would, therefore, be doomed to failure. Nonetheless, if Black Hat managed to set off sufficiently powerful fireworks near the blimp, it could potentially damage the skin, risking a loss of helium and possibly putting people in danger, which is likely why the advertising company is "real mad". The joke is that Black Hat would do something as destructive as attempting to destroy a blimp in flight, potentially killing people aboard or on the ground, merely to have the opportunity to use his H-alpha filter.

Cueball "responds" by holding whatever he's reading

closer to his face, apparently hoping to avoid further conversation (or consequences).

The title text references the insurance company MetLife, which until 2016 used the cartoon character Snoopy as an advertising mascot. In the Peanuts comics, Snoopy would frequently imagine himself as a fighter pilot in World War I in an aerial battle with the Red Baron, a battle he would frequently lose. The detail that Black Hat "dressed up as the Red Baron" might help explain another point: advertising blimps typically fly higher than the effective range of most fireworks. It would be entirely consistent with Black Hat's history to modify the stolen triplane mentioned in 496: Secretary: Part 3 to allow him to launch fireworks from the air, in mockery of an old-fashioned dogfight.

This comic was published shortly before Independence Day 2021, a US holiday that is often commemorated with fireworks. This may explain why Black Hat and Cueball originally had some fireworks around.

#2485: Nightmare Code

July 05, 2021



Charsets even used to be known as 'alpha-bets' before that word's obvious negative associations caused it to die out.

Explanation

Although the pandemic is not directly mentioned, this comic is another in a series of comics related to the COVID-19 pandemic.

A person using futuristic technology is giving a presentation or lecture. The content of his projected screen includes the names of the first four letters of the Greek alphabet, which he refers to as the Nightmare Code. The presenter expects that the list is familiar to his audience, but that it is novel information to them that it used to have a purpose other than providing arbitrary names to hurricanes, virus variants, and nanobot swarms.

The presenter refers to Greek as a language from Earth: this implies that the audience is mostly extraterrestrial - on Earth, everything is Earth implicitly. This may be the reason that they're unaware of the Greek language: the nightmare code may have spread beyond Earth, but a rather small Earth language may not be common knowledge.

Atlantic hurricanes and tropical storms are named once they have sustained wind speeds of 33 knots (61 km/h; 38 mph) or more. The names for these storms go from A-W each year (each letter has a name randomly chosen from a predefined list), with 21 names allocated each yearly period. When the 21 names are exhausted, Greek letters were once used to continue naming storms as needed, as referenced in 944: Hurricane Names. The

World Meteorological Organization decided not to use Greek letters when naming storms from 2021 onward. Perhaps in this vision of the future, the naming lists have given way to using the Greek alphabet exclusively.

Virus variants may also be given names once they are deemed sufficiently nightmarish. At the time of this writing, eleven variants of SARS-CoV-2 have been labeled with Greek letters. Previously, variants were named informally for the region in which they were identified (as were many viruses themselves), but this practice has ceased due to risks of discrimination and the perverse incentive of countries to suppress health information for the sake of saving face. A place may become (in)famously known as the origin of a disease by such a name, even if it originated elsewhere; an example is Spanish flu, which was actually first observed in the US state of Kansas. Nowadays vague names such as 'bird flu' or partly-informed geographic names tend to be better referenced by their hemagglutinin and neuraminidase subtypes, such as "H1N1" and "H9N2". The more technical coronavirus identification system uses a term such as "lineage B.1.617.2", whose awkwardness makes it unlikely to replace better-known names such as the "Kent variant" or "Indian variant".

Another set of historic nightmares the audience clearly knows about, which are still in our own future, are nanobot swarms, presumably nanoengineering failures and/or deliberate misuses of nanotechnology of the Gray goo type. Significant recurring or sequential events have seemingly earned the need to differentiate their

outbreaks, and Greek letters have been used to do this. One may even be tempted to speculate that the futuristic figure and his presentation equipment float in space because the Earth has been rendered uninhabitable as a result of one or more of said nanotechnology disasters.

The cultural forgetfulness about the neutral basis of the old letters, after perhaps who-knows-what nanobot disasters that may have scoured the Earth clean of all things Greek, has led to no other common use for them except for their use in identifying far too many crises. The words themselves thus are instantly associated to bad times for almost everyone.

The title text indicates that future people stopped using the term "alphabet" (which derives from the first two letters of the Greek alphabet, alpha and beta) due to the negative associations of the words caused by them being used to describe nightmarish occurrences. The "alphabet" is now called "charset", for "character sets".

The futuristic suit and gear are nearly identical to the ones worn by people in the future in 318: Nostalgia.

#2486: Board Game Party Schedule

July 07, 2021



Several of the guests are secretly playing Meta Board Game Party. Every minute of parallel debate in the breakaway faction earns double victory points!

Explanation

This comic shows a timeline of a gathering to play some sort of fairly complex board game. These games often have many pages of rules, and a long setup time. Often the very complex rules must be explained in detail, which can be extremely dull in a group environment.

Conversely, just beginning like at the time entry point "it will make sense once you play" without explanation often leads to new player frustration that, had they had a complete understanding, they would have made different choices and had a more reasonable chance at victory, or even worse, avoided constantly being informed of "illegal moves".

In addition, since it's a party, there are other activities that take place in addition to playing the game, notably ordering and eating food.

By the time you eat, prepare the game, and teach the new players, little time is left to actually play the game. This comic exaggerates this dynamic, for in the timeline, no one gets to play the game at all. Often during these gatherings the frustration with the factors above cause people to suggest settling on a simpler or more well known game.

The title text observes some of the guests supposedly playing a fictional board game, Meta Board Game Party – a game about board game parties. Because the quoted

rule states that arguing in the "breakaway faction" is worth more victory points, it would be optimal strategy for them to do just that, for as long as possible. This seems to be a sarcastic explanation as to why they tried to get the whole group to play some other game and turned the ensuing debate into 45 minutes of bickering.

#2487: Danger Mnemonic

July 09, 2021

NOW, REMEMBER:

IF RED TOUCHES YELLOW
AMID LEAVES OF THREE UNDER
A RED SKY AT MORNING,
YOU SHOULD PROBABLY
JUST GET OUT OF THERE.



It's definitely not the time to try drinking beer before liquor.

Explanation

The teacher Miss Lenhart warns two small kids using a danger mnemonic.

However, this is actually a mash-up of three different common danger mnemonics, each of which warn about different hazards.

- Red touches black, that's a friend of Jack; red touches yellow, you're a dead fellow.

This mnemonic is intended to help recognize venomous coral snakes, which have brightly colored stripes. Some nonvenomous king snake species have similar striped colors, but in different patterns. **NOTE THAT THIS MNEMONIC IS NOT ACCURATE, ESPECIALLY OUTSIDE THE EASTERN UNITED STATES WHERE IT WAS ORIGINALLY CREATED;** many species of coral snake have black stripes touching red stripes, and if the snake has atypical coloration, then the rhyme may still lead to misidentification even in the right region. The safest course of action is to avoid any snake with the warning colors of red, yellow/white, and black stripes. Another corruption of the same warning features in 1604: Snakes.

- Leaves of three, leave them be; berries white, poisonous sight. (Alternatively, "berries white, run in fright" or "hide from sight.")

This mnemonic is used to identify poison ivy and poison

oak throughout much of North America. These plants both produce an oily surface resin called urushiol, which causes an allergic reaction in the majority of people. Touching either plant can result in contact dermatitis, which can be severely itchy or painful. If burned, the urushiol can be inhaled, causing lung irritation. While rarely serious, these reactions are often severely unpleasant and can last for weeks, so avoiding the plants is well advised. Both plants generally grow three leaves at the end of each branch, and grow berries that turn white when ripe. The mnemonic helps in remembering this characteristic to distinguish them from similar-looking but harmless vines. See 443: Know Your Vines.

- Red sky at night, sailor's delight; red sky in the morning, sailors take warning.

This mnemonic predicts bad/good weather conditions based on a particularly red sunrise/sunset. It is predictive at middle latitudes where the prevailing winds go from west to east. Regions of higher air pressure will cause a particularly red sky at sunrise/sunset, so a red sky in the evening indicates a high pressure system is coming in from the west with its calmer weather, while a red sky in the morning indicates a low pressure front coming in (usually with rain and rougher weather). In some countries (such as the United Kingdom), the saying mentions shepherds rather than sailors. Randall actually wrote a newspaper article explaining this phenomenon.

Combining all three sayings sounds particularly ominous. It implies that a person is involved with a

situation simultaneously involving coral snakes, poison ivy, and potentially nasty weather. In such a case, Miss Lenhart advises the children to "just get out of there", implying that the situation is too dangerous to try to deal with.

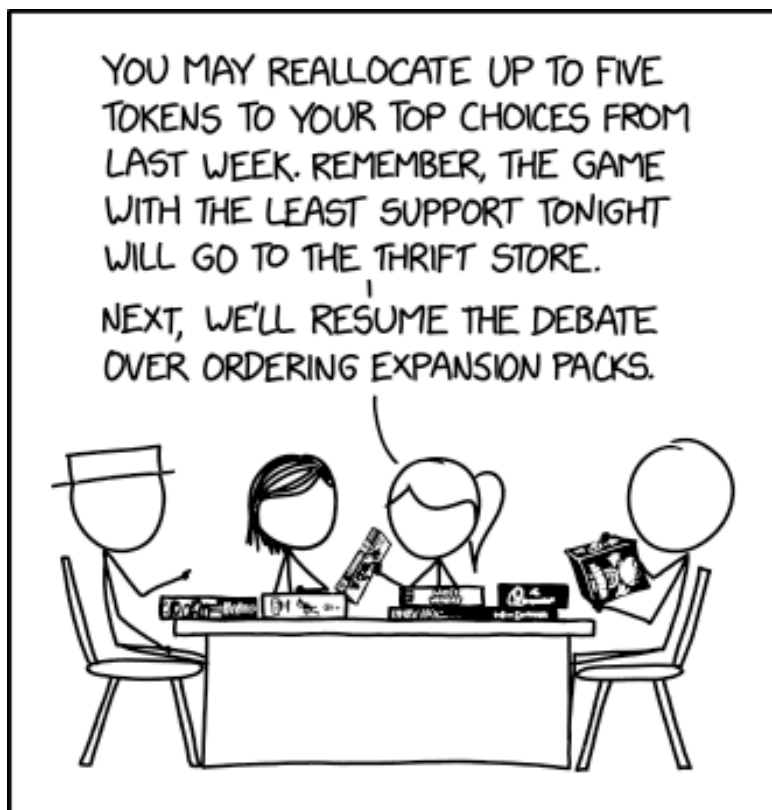
The title text refers to another mnemonic: 'Beer before liquor, never been sicker; liquor before beer, you're in the clear.' Unlike the first three mnemonics, which are genuinely useful for avoiding danger, this one is largely a myth, as the order in which you drink alcohol is unlikely to impact how sick you become. However, whether the mnemonic is true or not, testing it would involve multiple drinks of alcohol, which would be ill-advised when facing a dangerous situation, particularly one as bizarre and complex as implied in this strip.

See also 2422: Vaccine Ordering for the previous time xkcd referenced the latter mnemonic.

See also 2038: Hazard Symbol for another combination of danger warnings.

#2488: Board Game Argument: Legacy

July 12, 2021



WE GOT TIRED OF HAVING THE SAME REPETITIVE ARGUMENTS EVERY WEEK OVER WHICH GAME TO PLAY, SO WE DEVELOPED BOARD GAME ARGUMENT: LEGACY.

Listen, you need to get over your reluctance to permanently alter a game. Now roll 2d6 to determine how many ounces of soda to spill into the box.

Explanation

This comic continues the joke from comic 2486: Board Game Party Schedule, released the previous week, about the difficulty some gaming groups have actually playing any game at all once they get together. In this scenario the group have leveraged the difficulty of choosing a game into a game itself. It seems to be that each player has a certain number of votes, or tokens, that they can use to decide which game to play, with the added element that they permanently dispose of the losing game. This can lead to strategic play where a player might vote for a game, even if they don't want to play it that night, so that they could still play it at some future resolution of the choosing.

Once the voting is finished, the next phase of the game is to debate which expansion packs they should collectively buy for which game.

A legacy board game is one where players change the game itself in the course of play, such as by writing on certain cards and ripping up others, causing future sessions to be modified. A legacy game thus avoids the tendency of some games to become repetitive if they are played every week, which is a common tradition among friends or families. The meta-game this comic describes fits this definition, because the available pool of games (and expansion packs) changes based on the players' decisions. Randall refers to the “game” of choosing what to play having become repetitive. Although official

legacy games are sold by the manufacturers of the original game, some players may create their own legacy versions of a game.

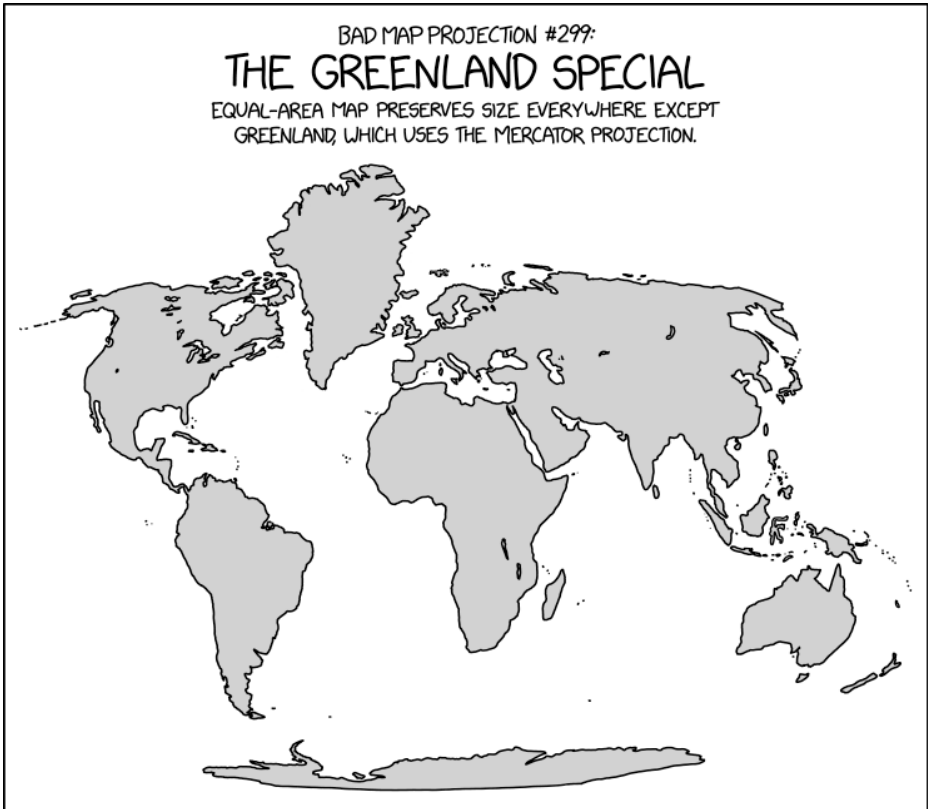
The title text refers to how many board and card game owners are bothered by legacy games because they destroy game pieces. A legacy game, of course, is meant to be permanently altered, but many players find it hard to perform destructive actions like cutting or tearing up cards. At an extreme, some owners wish to keep their games in as-new condition, going as far as refusing to shuffle cards in ways that bend them, or not punching tokens out of their cardboard frames. Even some games not classed as "legacy" games may have elements such as blank cards to be filled in by the players. For those who are reluctant to make changes, these items may remain blank forever. An additional layer of humor comes from the fact that it sounds like the speaker is chastising a game owner who does not want to engage with ordinary elements of the game, but instead urges them to pour soda on the game (something that would usually be an unfortunate accident). "2d6" is standard notation for games that involve rolling several different types of dice, where the first number refers to the number of dice to be rolled (in this case 2), and the second number referring to the style of dice (in this case 6-sided). That means that the player could end up pouring between 2 and 12 ounces of soda (inclusive) into their game box, depending on the total value rolled on the two 6-sided dice and assuming the dice roll directly translates to ounces.

The board game boxes visible in this comic are real board games (from left to right):

- Mall Madness (Electronic)
- Wingspan
- (to be determined)
- Wits & Wagers
- The Classic Dungeon
- Obsession
- Medium

#2489: Bad Map Projection: The Greenland Special

July 14, 2021



The projection for those who think the Mercator projection gives people a distorted idea of how big Greenland is, but a very accurate idea of how big it **SHOULD** be.

Explanation

This is the fourth comic in the series of Bad Map Projections displaying Bad Map Projection #299: The Greenland Special. It came one and a half year after the third 2256: Bad Map Projection: South America (#358), and was followed about 10 months later by 2613: Bad Map Projection: Madagascator (#248).

Map projections are different methods of representing the curved surface of the Earth on a two-dimensional map. There's no perfect way to do so. Because the Earth is not flat,[citation needed] any 2D map projection of it will always distort in a way the spherical reality, and a map projection that is useful for one aspect (like navigation, geographical shapes and masses visualization, etc.) will not be so for all the others. Typically a projection can represent only distances, areas or angles correctly, or at best imperfectly compromise two of these. The map choice should reflect the purpose you need to put it to, as it will necessarily distort (perhaps by twisting, skewing and/or resizing) those aspects it was not designed to show intact.

One such projection is the Mercator projection, which is designed so that all north-south lines of longitude are parallel to each other and all rhumb lines are consistent, which is most important in the time of map-based navigation. In reality, apart from the direct east-west directions, all the imaginary straight lines eventually meet at the poles - even if they look parallel. The apparent

distance between lines of latitude at the more extreme latitudes expands and the vicinity around each pole can never be drawn, as Mercator maps show geographic features plotted over ever larger map areas and distances than they should, for those nearer the poles, compared to those more equatorial. It is not possible to accurately compare the sizes of features across the globe using this projection, although the distortions can be effectively ignored for more local maps that do not plot a significant area of the globe (other than very close to the poles, historically not an issue) and along or between any given narrow strips of latitude away from the equator the comparison is between near equal scalings.

Greenland is a large (2.17 million square kilometers of surface area) island in the Arctic ocean and one of the nearest pieces of land to the north pole. The Mercator projection shows it to be significantly larger than it really is, compared to equator-straddling features such as Africa. It is therefore one of the most obvious inaccuracies of Mercator's map, if used (e.g.) in the classroom to teach physical geography (which perhaps would best use a representation that was consistent to area) rather than navigation.

The equal-area projections such as Mollweide or Tobler Hyperelliptical, the latter of which seems to extremely closely match the majority of the features evident upon the hand-drawn map, ensure that shapes contain the same relative proportion of area as they would upon the original spherical (or slightly spheroidal) surface, across all latitudes, but only by bending the directions and

rescaling the distances ever more drastically the closer to the map edge (the anti-meridian to that the map is centred upon) you go. Unlike the Mercator projection, you can show the poles (as the extreme upper and lower limits of the rim) from an equatorially-centred view, and every point of the Earth is given one definite position (or two, where they lie exactly upon the crossing point between the left/right extremes of the map).

This comic's projection has retained this singular inaccuracy as a deliberate feature, though avoiding all other such inaccuracies of the Mercator projection by using a different projection elsewhere that is designed explicitly to avoid them. For example, a traditional Mercator map would show other polar areas such as Antarctica, southern South America, or even New Zealand as larger, but this map does not.

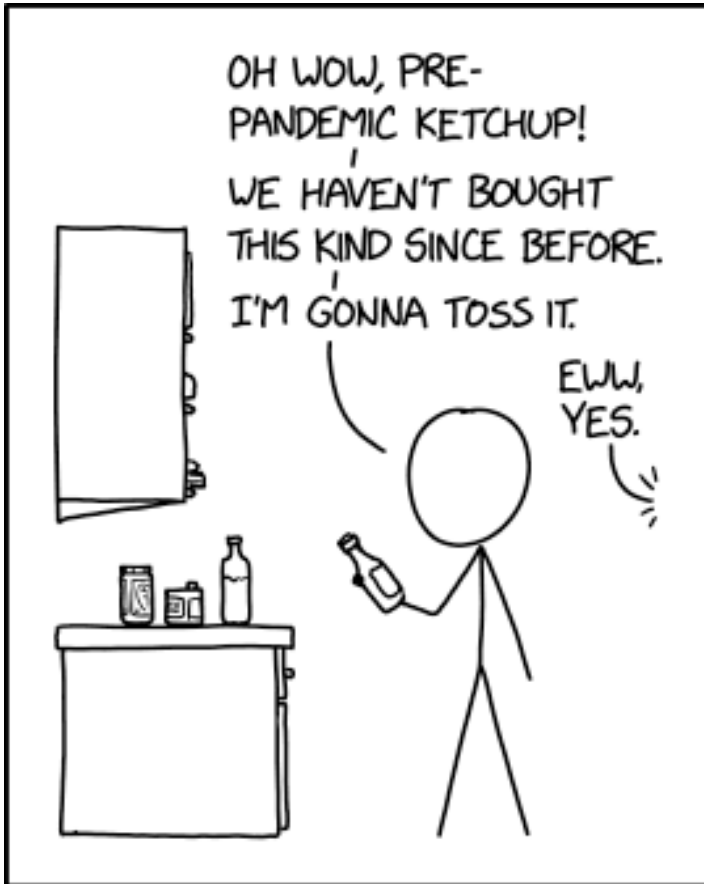
Although it may not be obvious, due to no land-masses being normally shown at/close-enough to the North Pole, the Mercatorish Greenland actually extends beyond the Elliptic map's northern limits into positions that do not even exist in reality - it does not even 'wrap around and over' the pole (like a bad toupée) but passes through it and the arbitrary back-edge meridian line and into purely imaginary space that does not exist upon the surface of the Earthly sphere. (For a flipped comparison, the lower 'curve' of Antarctica is not its coast, but merely the map's 'wrap-around' edge where a further step would have you stepping back onto the continent at a second point of this nominal edge. The true coast of Antarctica is only the rough upper edge, passing between the two

points which each represent the one arbitrary 'wrap-around' coordinate that is opposite-but-adjacent on the map's oval edging, i.e. at $\pm 180^\circ\text{E/W}$, but which otherwise has no particularly special quality 'on the ground'.)

The title text suggests that this map was created for people who believe Greenland should be larger. Whether these people believe it should be physically increased in size in some manner or should simply receive a greater share of the attention is unclear. One method for increasing its size would be to increase the coverage of its ice cap, which is currently decreasing in size due to increases in temperature. However, increasing Greenland's ice coverage to the size it appears on a Mercator map would involve covering the entire island and surrounding ocean with ice, which would be very problematic for Greenland's population.[citation needed]

#2490: Pre-Pandemic Ketchup

July 16, 2021



SPRING 2020 FORMS A WEIRD
DIVIDING LINE IN MY KITCHEN.

I wonder what year I'll discard the last weird food item
that I bought online in early 2020.

Explanation

This comic is another in a series of comics related to the COVID-19 pandemic.

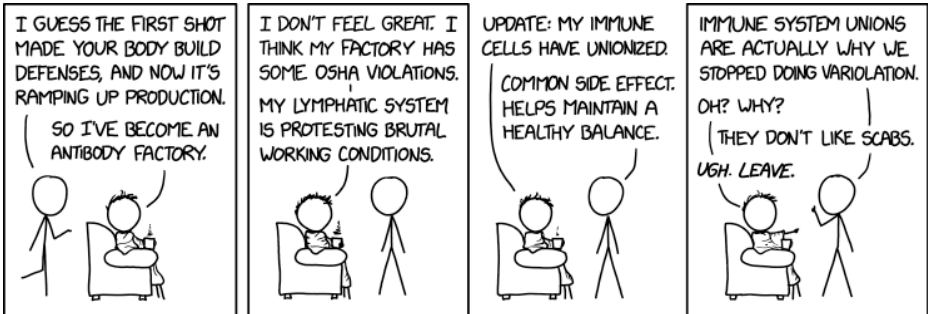
Just like 2474: First Time Since Early 2020, Randall compares the pre-pandemic life and the post-pandemic life in this comic. Life has changed dramatically due to the COVID-19 pandemic and the subsequent lockdowns and restrictions by governments around the world.

In this comic, Cueball bought a bottle of ketchup before the pandemic and they have not bought that kind of ketchup since, possibly due to supply chain disruptions or that brand not being available to order online. It may be a reference to the shortage of ketchup packets caused by an increase in takeout orders and restaurants replacing the ketchup bottle on the table with single serving units.[dubious] Cueball is now cleaning out his cupboard, perhaps as a form of "pandemic spring cleaning" to make way for the future, and considers throwing it away. An offscreen character encourages him to toss it.

In the title text, Cueball (or possibly Randall) is wondering in which year he would discard the last weird food item that he bought online in early 2020. If he's going for the Expiration Date High Score to beat Megan's high score of 24.3, he should probably wait until 2045 or so.

#2491: Immune Factory

July 19, 2021



In the final vote, the doubters were won over by the strength of the name **IMMUNION**.

Explanation

This comic is another entry in a series of comics related to the COVID-19 pandemic, specifically regarding the COVID-19 vaccine.

When Hairy received his first dose of a COVID-19 vaccine, his body began building a defense in the form of antibodies. He has now received his second shot, and is feeling even more unwell than the first time, since his body has ramped up the production of antibodies, as Cueball states. Hairy and Cueball then begin to make comments that metaphorically compare Hairy's immune system to a factory, hence the title Immune Factory.

Vaccines in general work by giving the body's immune system a chance to respond to a pathogen without actually being infected. The immune system responds by producing antibodies, proteins customised to attach to the pathogen, either disabling it directly or marking it for attack by immune cells. After the vaccine (or after an actual illness), the immune system remembers how to make the antibodies and can more quickly respond to future infections. This is why Hairy describes his body as an "antibody factory".

However, many common symptoms of illness (such as fever, soreness, diarrhea and nausea) are actually caused by the body's immune response rather than the infection itself. As a result, vaccines can result in similar symptoms to an illness, albeit milder and of shorter duration.

Hairy extends the "body as factory" metaphor by complaining that, since he feels unwell, the factory must be violating OSHA regulations—that is, rules that protect workers from unsafe work conditions. Hairy says his lymphatic system (a major component of the immune system) is protesting the "brutal" work of responding to the vaccine, as human workers might protest a dangerous workplace.

In real workplaces, one possible response to worker dissatisfaction is for them to unionize, forming an organization that can use their solidarity to bargain for improvements to working conditions. Hairy says that this is what his immune cells have done. It is not clear whether this corresponds to any actual part of the immune response, or whether it is simply a humorous expansion on the "factory" metaphor.

Cueball uses the "union" statement to set up a pun on two meanings of the word "scab". If unions make demands that an employer refuses, their workers may strike, or refuse to work. Employers may keep the workplace running by hiring strikebreakers, non-union workers (or union workers who break ranks with their colleagues). Union members may refer to strikebreakers by the pejorative term "scabs".

Another meaning of "scab" is the hard coating the body produces to cover a bleeding or seeping wound while it heals. Smallpox is a dangerous illness that causes ulcers upon the skin, leading to many small scabs forming as those ulcers heal. Prior to modern vaccination

techniques, people were sometimes deliberately infected with smallpox—typically from a person with a mild case—while they were healthy. This process, now called variolation (after Variola, the virus that causes smallpox), could be done in various ways. Some methods used pus or fluid from smallpox ulcers, but others used scabs from the ulcers, dried and powdered. This powder might be rubbed into a cut in the skin, or insufflated (blown up the person's nose).

The pun therefore is that members of the immune system union would not like either kind of scab. Hairy finds the pun appalling, and tells Cueball to leave.

The title-text parodies the trend for recent incarnations of unions to rebrand or form anew with a descriptively apt name (possibly with a forced acronym, or styled as one for branding purposes), rather than the (Extended/Very Extended/etc) Three Letter Acronyms of times past. In this case making a portmanteau of "immune union" - IMMUNION. The cleverness of this name apparently convinced some of Hairy's immune cells that were previously opposed to the union to change their minds and join the union.

Actual OSHA regulations that may be broken by the antibody factory, if OSHA regulations applied[edit]

- 1910.1030(d)(1)

General. Universal precautions shall be observed to prevent contact with blood or other potentially infectious materials. Under circumstances in which differentiation between body fluid

types is difficult or impossible, all body fluids shall be considered potentially infectious materials.

This would be broken because the immune system necessarily is in contact with blood and other bodily fluids.

#2492: Commonly Mispronounced Equations

July 21, 2021

COMMONLY MISPRONOUNCED EQUATIONS

$$F = G \frac{m_1 m_2}{r^2}$$

FUH-JAM-ER

$$E = mc^2$$

EM-CAH-TOO

$$a^2 + b^2 = c^2$$

AT-BOOT-COOT

$$A = \pi r^2$$

APP-ER-TOO

$$H = -\sum p_i \log p_i$$

HA-SPLOG-PEE

$$PV = nrt$$

PAV-NURT

$$e^{i\pi} = -1$$

EYE-PIN

$$F = ma$$

FEE-MAH

$$\frac{\partial^2 u}{\partial t^2} = c \frac{\partial^2 u}{\partial x^2}$$

DOOT CAH-DOOX

$$f'(x) = \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h}$$

FAX-LIM-OH FAX-UH-FOX

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

ZA-BO-BA FAK-TOH-AH

"Epsihootamoo doopsiquorps" --the Schrdinger equation for the hydrogen atom

Explanation

This comic is a collection of very commonly used physics and mathematical equations, along with their "correct" pronunciations. Equations are normally voiced out loud either by their names ("mass-energy equivalence") or by saying the parts out loud using normal linguistic rules ("E equals m c squared"). This comic instead asserts that equations are meant to be said out loud like words, using their own set of phonic rules.

Though the premise may initially seem absurd, some nerds have both the trait of using equations as commonly as others might chat and that of finding it entertaining to coin amusing new words ("input", "pwn"). Saying the equations more rapidly can speed up work or make work seem more enjoyable. This phenomenon is called clipping.

Using clipped or verbalized forms of equations is sometimes standard practice within a given field. The equation for continuously compounding interest $A = Pe^{rt}$ is commonly taught and discussed as the "pert" equation, while the definitions of the main trigonometric functions is similarly taught and discussed as SOH-CAH-TOA: sine = opposite/hypotenuse, cosine = adjacent/hypotenuse, and tangent = opposite/adjacent. These particular "corrections" are all nonstandard, however, occasionally conflicting with more normal readings like "pivnert" for the ideal gas law. The "corrections" are also internally inconsistent, with equal

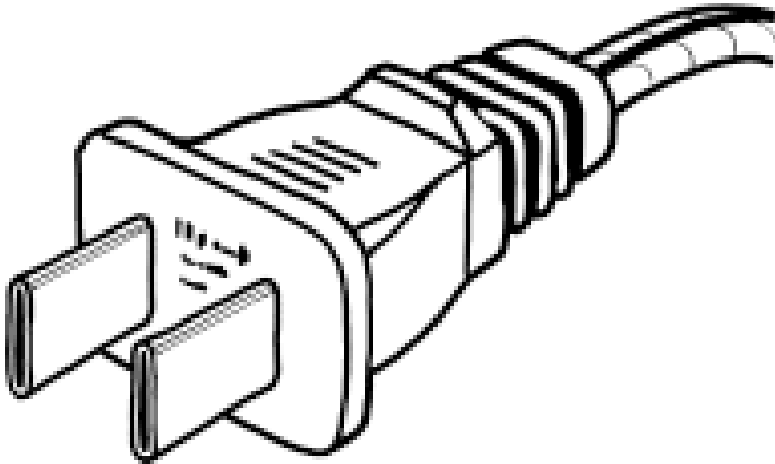
signs and exponents sometimes omitted and sometimes included and intermediate vowels.

Equations[edit]

#2493: Dual USB-C

July 23, 2021

CURSED CONNECTORS #187



DUAL USB-C

Small devices use two-prong USB-AC, but there's also a three-prong version with a USB-B plug as the ground.

Explanation

This comic was the first in what became a new series of Cursed Connectors and presents Cursed Connector #187: Dual USB-C. The series continued two comics later with 2495: Universal Seat Belt (#65) and was followed three weeks after that by 2503: Memo Spike Connector (#102).

Starting roughly around 2016, the word "cursed" has become slang for something that makes the user feel uncomfortable (unlike the classic definition, nothing supernatural needs to cause the discomfort).

USB-C connectors are the newest version of the USB standard, and Randall showcases a new type of connector which would see two USB-C plugs side-by-side able to be inserted simultaneously by housing them inside a NEMA 1-15P plug, more commonly known as a Type A plug, that is usually used in some countries to connect electrical devices to AC current. This does not seem to offer any advantages over the current implementation.

Further, the plug introduces several disadvantages, including, but not limited to

- The plug creates the risk of accidentally plugging a USB-C device into a power outlet, which is likely to damage the device as the voltage of a NEMA 1 circuit is about six times as large as the maximum for USB-C.

Additionally, mains power outlets typically supply alternating current, whilst USB devices operate on direct current, which is also likely to result in damage to the device.

- The outer metal casings of the plugs are usually connected to the device's ground plane, so the casings likely have a low-resistance path between them. Plugging such a device into a power outlet would form a short circuit.
- The plug likely won't fit a power outlet (NEMA plug pins have a 6.4×1.5 mm cross-section and the USB-C is 8.4×2.6 mm.). This is probably good, as it reduces the risk of either of the two hazardous situations described above.
- Any device meant to be connected to the full plug would need vertical ports, making any theoretical device quite thick.
- The plug could occupy 6+ ports of a USB-C hub with vertical ports, taking up the space to charge 2-6 phones with a single device.
- The plug being mimicked is typically not found in a double male configuration implying that the cord is attached to a device at the other end in a non removable way (Typically, the other end of detachable power cords for appliances is one of the plugs specified in the IEC 60320 standard, so presumably for Randall's connector application would substitute USB-C sockets in a C9 or similar configuration.)

The connector therefore is considered cursed.

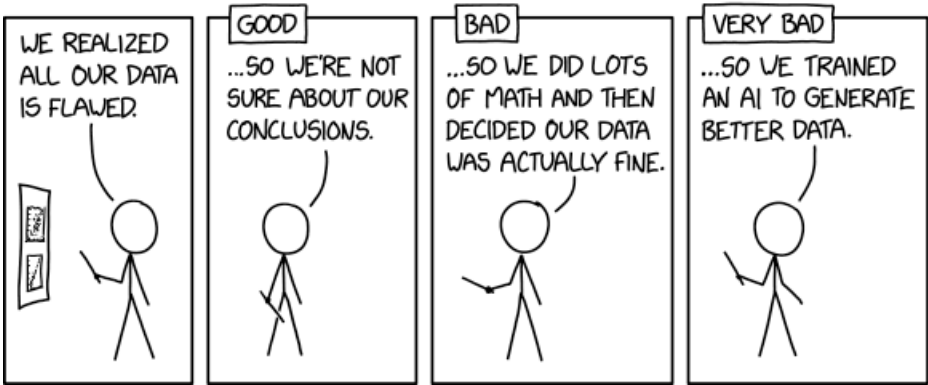
Notably, there's an existing dual USB-C plug in use for Macbook-compatible high-performance dongles, among other things, which is remarkably similar but avoids all the above disadvantages. It instead invites confusion with the NEMA 6-15 connectors.

The title text indicates that an equivalent for the 3-pronged NEMA 5-15P plug (a.k.a the Type B plug) for AC current could be created easily by incorporating a USB-B plug, which are small and square-shaped and could therefore function as the ground prong. There appears to be no reason to do this other than because both names contain the letter 'B'.

Unconventional uses for electric plugs are a recurring topic in xkcd (see 1293: Job Interview and 1395: Power Cord). Combining them with USB was previously explored in 1406: Universal Converter Box among other combinations.

#2494: Flawed Data

July 26, 2021



We trained it to produce data that looked convincing, and we have to admit the results look convincing!

Explanation

This is another comic about what is the right or wrong way to perform research when data are not adequate.

In the first frame, Cueball presents a report on a poster (two graphs with data points and possible fitted curves), admitting that all of the data are actually flawed. He doesn't explain if it's contrary to some outcome or revelation, or perhaps a systematic error in the data-gathering process.

From there, three different reactions to this is displayed in order of how good a decision they make based on this realization.

In the first scenario Cueball states they are no longer sure about the conclusions they had drawn from the flawed data. This is, of course, the scientifically appropriate decision. The less reliable data are, the less reliable the conclusions that can be drawn. Ideally, flawed data would be discarded altogether, but there are situations in which better data are not available, so a compromise may be to draw tentative conclusions, but make clear that those are uncertain, due to issues with the data.

In the second scenario Cueball then explains that after heavy manipulation ("doing a lot of math") of their flawed data, they decided they were actually fine. There are a number of methods that can be used to manipulate or "clean" data, with varying levels of complexity and

reliability. Some of these methods may be valid in certain situations, but applying them after the initial analysis failed is highly suspect. The likelihood, in such a case, is that the researchers tried different methods of data manipulation, one after another, until they found one that gave the results they wanted. This is clearly highly subject to the biases of the researchers (both conscious and unconscious) and is much less likely to result in accurate conclusions. Hence, this approach occurs in research more often than it should, and Randall is making clear that it's "bad".

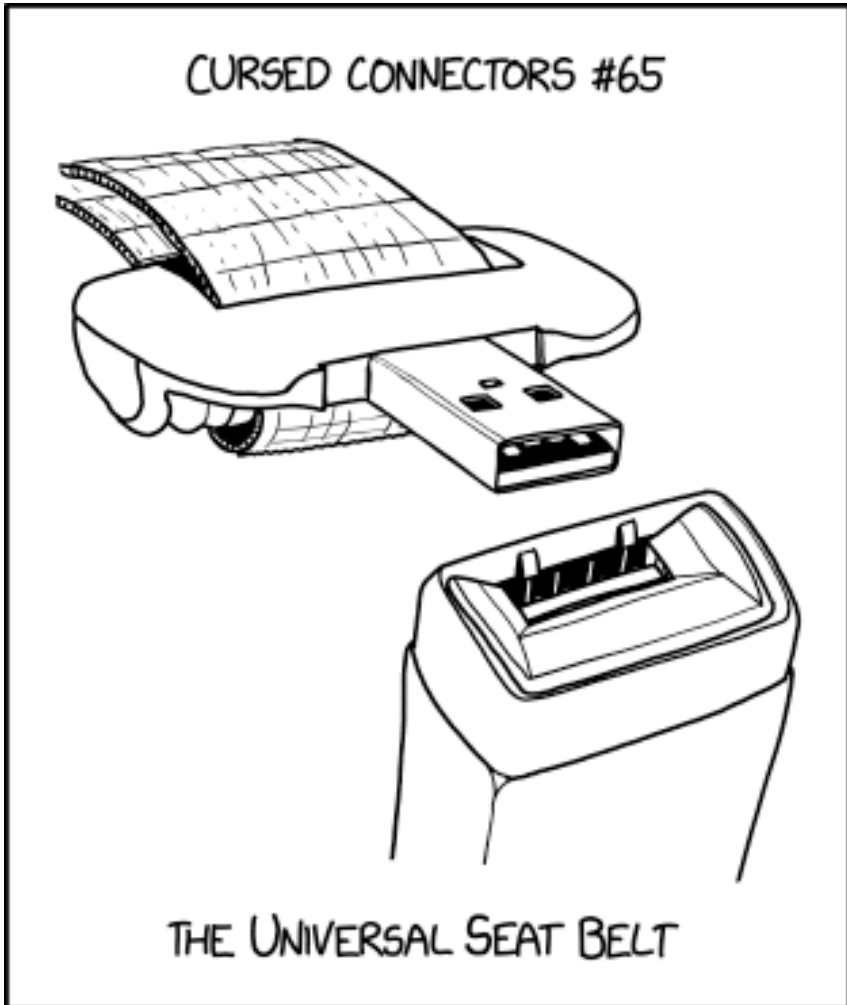
In the third and final scenario, Cueball explains that they scrapped all the flawed data. However, instead of trying to make some new data by correctly redoing research/measurements/tests, they instead trained an Artificial Intelligence (AI) to generate better data from nothing but a desire to match a target outcome. These are of course not real data,[citation needed] but just a simulation of data, selectively sieving statistical noise for desirable qualities. And since they are probably looking for a specific result, they are training the AI to generate data that support this. This approach is "very bad", as it not only produces no useful science, but means that future researchers will be working from entirely artificial data. Doing so would be destructive to science and would be considered incredibly unethical in any research body or association. The only purpose of such a method would be to convince others that you'd proven something interesting, rather than determining what's true (and possibly gain some experience in AI

programming). AI is a recurring theme on xkcd.

In the title text, the results from the very bad approach are mentioned and the fact that they got the data they were looking for is made clear when they state that We trained it to produce data that looked convincing, and we have to admit, the results look convincing! The AI was of course trained to provide data that look convincing, which is why they are so convinced of the results.

#2495: Universal Seat Belt

July 28, 2021



The plug fits really snugly, so it should be safe in a crash.

Explanation

This became the second installment in the series of Cursed Connectors and presents Cursed Connectors #65: The Universal Seat Belt. The series began two comics earlier with 2493: Dual USB-C (#187) and was followed three weeks later by 2503: Memo Spike Connector (#102).

The comic shows another of Randall's "Cursed Connectors", the "Universal Seat Belt" — a pun on the Universal Serial Bus (USB) connector — which would have the same abbreviation of USB.

USB connectors are mostly designed for free and unrestricted insertion and removal. There may be a slight use of the internal and external bumps and dimples to provide a tactile indication of being engaged or disengaged, but there are usually no facilities to prevent a connector being easily pulled out of even a port being actively used - the OS can do no more than complain that a device has been removed without first ensuring proper logical unmapping of the resource (which in turn may have to await a current session of data transfer being completed or aborted) or warn that a "delayed write" has failed. Anyone who has used USB in a frequently-jostled environment knows the connectors can't withstand much jerking around without their connection to their mainboard permanently failing.

Car seat-buckles, on the other hand, have very definite

requirements to not come loose unless intentionally and mechanically released, in order to keep the passenger safely anchored to the seat.

The title text claims that the seat belt is secure in the case of a crash. This is another pun, as seat belts protect passengers in a car crash while USB standard is designed to protect the computer in the event of a device hardware malfunction.

Another similarity between seat-belts (especially on back seats) and USB-plugs is that they can be a bit fiddly to insert. A seat-belt lock with the asymmetric design of a USB-A plug would be even more fiddly and thus "cursed".

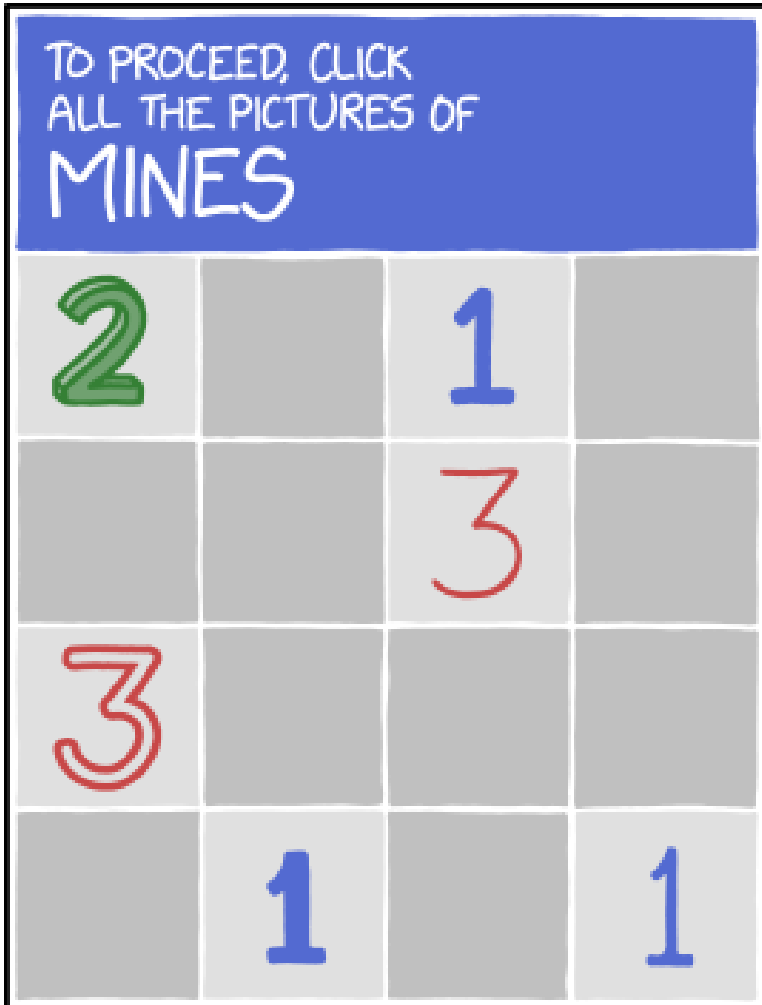
One possible use for the USB data connector might be to give a certain degree of 'proof' that the belt is plugged in, although that functionality is fairly well covered by current anchor-point sensors that (combined with seat-occupancy sensors that may respond to the weight of a seated person) can trigger dashboard lights and possibly warning sounds in vehicles as necessary to prompt correct usage of restraining belts. That system does not usually need an electronic data connection between anchor and belt, an anchor-side switch should suffice, and it would still require a mechanical gripping/hooking method to make it of any use to be engaged in the first place.

The USB specification is designed such that USB connectors fit snugly from pressure. This means they

usually need no button, like seatbelts have, to lock them in place. If one hacks a USB connection to increase the tightness, so that it can withstand more force applied to it and still hold its function, it becomes much harder, or even impossible, to insert and remove. Randall has removed the button, such that the connectors are a "cursed" misleading and dangerous use of similar form.

#2496: Mine Captcha

July 30, 2021



This data is actually going into improving our self-driving car project, so hurry up--it's almost at the minefield.

Explanation

This comic, like 1897: Self Driving, references the approach of using human-entered CAPTCHA inputs to solve machine learning problems, particularly those involving image classification.

In order to prevent automated programs from using web services, Google offers a protection called reCAPTCHA, which performs various tests to see if a user is human or machine. One of these tests is a "I'm not a robot" checkbox which must be checked in order to proceed, although ticking the box is merely a formality, and later versions of reCAPTCHA can simply perform the tests quietly in the background without needing user consent.

If the reCAPTCHA system suspects that the user may be an automated bot, it presents an image recognition challenge that only humans should be able to pass. This has the desired effect of denying access to robots, but it also has a side benefit that the human input can be used to train Google's image recognition software. The challenge usually features a square grid of images, typically things one might see while driving - e.g. "Check all squares containing a stop sign". If the user clicks enough correct squares, they are permitted to continue.

Minesweeper, on the other hand, is a logic puzzle game in which the player is presented with a grid of unrevealed squares and must deduce the location of mines that have been secretly hidden on random squares. The game

provides clues by marking some squares with the number of mines (up to a maximum of 8) that are adjacent to that square; by carefully considering the possibilities, a player can deduce which squares must contain mines, and mark them with flags to avoid clicking on them. Revealing a mine loses the game.

In this comic, Randall combines the two concepts to create a "Mine Captcha", which is presented in the form of a reCAPTCHA challenge but actually appears to be a mini game of Minesweeper. To be more precise, it is actually the opposite of regular Minesweeper. This challenge invites the user to click on the mines, as opposed to Minesweeper's aim of clicking only upon unrevealed squares that are not mines. Furthermore, within the terms of a reCAPTCHA, there are no pictures of mines displayed, to click upon. This is also the case for Minesweeper, as they only appear once the game ends, all remaining hidden during play and thus needing to be deduced where they all are.

A real-world Mine Captcha would be somewhat ineffective for a variety of reasons. Firstly, not every human would recognize a game of Minesweeper and therefore wouldn't understand what they are being asked to do. Even if they do recognize the game, they may not know the logical method for deducing the locations of mines. Additionally, even for skilled players, there is a trap in that the Captcha's objective is the reverse of regular Minesweeper; they might therefore get tripped up by muscle memory and click on something that is not a mine, which would fail the challenge.

Another issue is that games of Minesweeper can sometimes involve a degree of luck, as it is possible to generate a puzzle which does not give sufficient information to unambiguously deduce the location of every mine. This may not be a problem since Randall's Minesweeper is only a four-by-four grid. In these situations, the most a player can do is click the uncertain square and hope for the best. If the Mine Captcha is poorly implemented in this way, this would increase false negatives in human detection due to some humans failing the captcha purely due to bad luck. Some variants attempt to eliminate this problem: Mine Detector, for example, is a variant game which provides better information, such that it's almost always solvable without guessing except at the highest difficulty level.

Finally, a Mine Captcha would actually be fairly easy for an artificial intelligence to solve, since it is a logic puzzle: as long as the AI can read the numbers, it can simply use an algorithm to eliminate all impossibilities until it has the correct answer. With a 4x4 grid it's even easier than that: a computer could quickly brute force the problem by trying every possible arrangement of mines until it has the correct one.

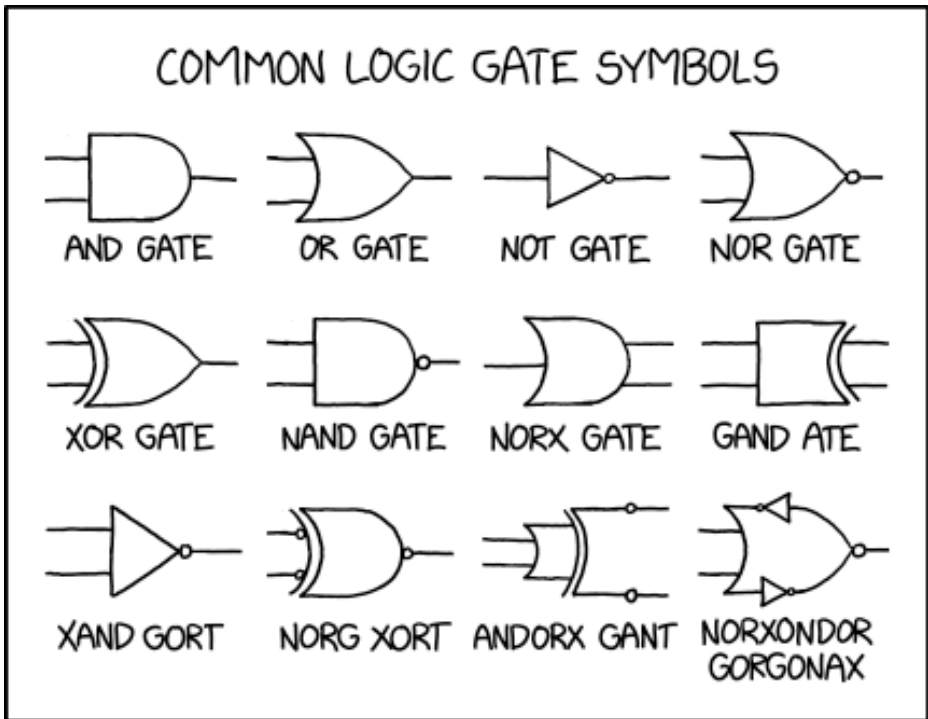
It seems that Randall predicted that an AI might try to solve the captcha itself, as he rendered each numeral in a different style; this is similar to obfuscation methods used in text-based captchas to prevent automatic text recognition software from reading the captcha. However, it would not be very effective in this case as the same numbers have the same color; an AI could simply

recognize the color instead, which is even easier for an AI than trying to read a number.

The title text is similar to 1897: Self Driving where the CAPTCHA solver is asked to answer quickly, implying that the training data is actually a real-world situation being experienced by a self-driving vehicle at that very moment. The joke here is that real-life minefields do not have large numbers indicating which of the surrounding land contains mines[citation needed].

#2497: Logic Gates

August 02, 2021



In C, the multiocular 0 represents the bitwise norxondor gorgonax.

Explanation

The comic lists logic gates. The first six are real but the last six are made up and get increasingly absurd. The names for these last six use the same letters and syllables as the first six so as to appear at a glance to be consistent with their naming conventions.

Some of the ways the gate parts are combined seemingly-impossibly can raise ideas in the mind of the reader of how quantum computing involves processing multiple possibilities at once, or how machine learning involves solving systems backward from their outputs to their inputs. The names ring of calling more and more profoundly to some mythological catastrophe.

The only real-life logic gate that was omitted is the XNOR gate (short for "eXclusive Not OR"; it compares the inputs, and if and only if they are equal, it outputs true). Note that the "NORG XORT" gate would be logically equivalent to it, if it were tipped to match its uniquely XOR-style tail, since it would then be an XNOR gate with NOT on both inputs, a modification that has no ultimate effect on the logic as it merely switches the case of which exclusivity it needs to be, and does not care which version of same-input it might be responding to.

A double-NOT on an input would produce the identical output again (...if the input is not not true). Two NOTs preapplied to a (N)AND or (N)OR would produce the

same output as a (further-)NOTed version of the (N)OR or (N)AND, conversely (...if not-1 and not-2 then this also means that neither 1 nor 2). Normally this would be shown, if necessary, as full NOT gates on the lead-in inputs but (see Transcript, below, and the NORG XOR description above) the shortcut element is occasionally used in further mix'n'match symbology (together with reinterpreting connectivity lines as partial shape-edges and vice-versa) in 'understandable' but definitely non-standard ways.

Along with the deliberate confusion of connector and shape-edge lines, directionality is also played with in several cases, with input 'ends' perhaps also at the (implied) output end and reversed sub-symbols implying a composite gate with substructural feedback or perhaps diode-rectification upon a bidirectional logic path.

Much like 2360: Common Star Types, as the list progresses, the names start to sound more like mythical creatures, closing with the "Norxondor gorgonax". As with the symbology, the names appear to be nonsensical recombinations of the standard ones (perhaps with off-subject inspirations, in some cases) but often do not match up with the symbolic (mis)use, such as an X in the name not implying/being implied by an XOR's unique drawn feature.

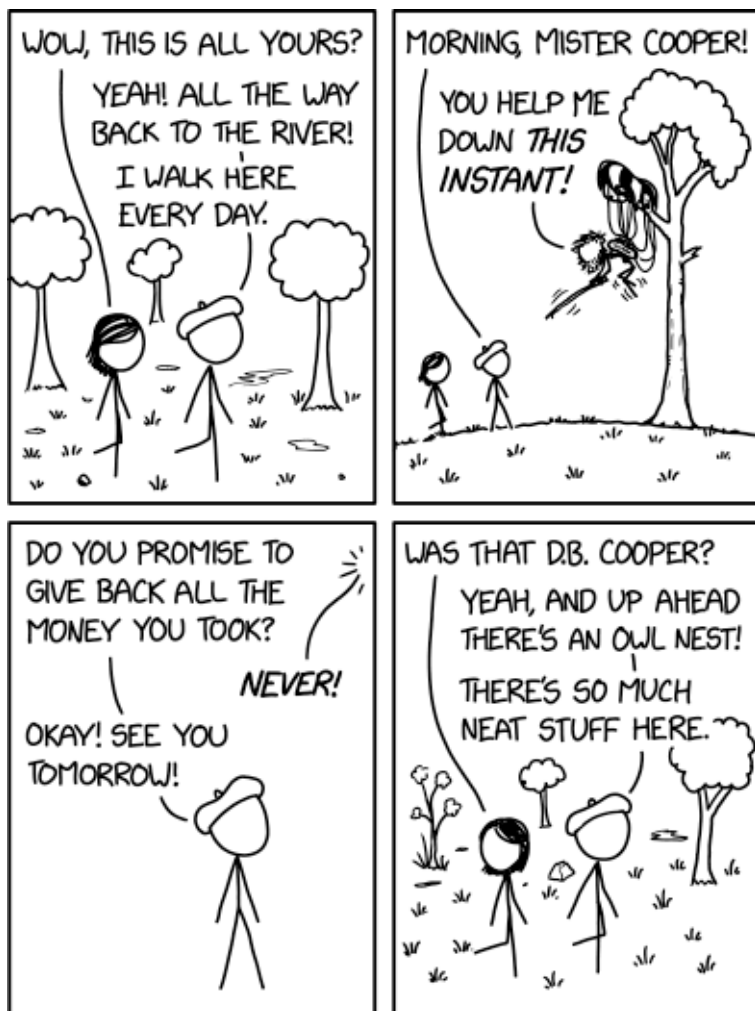
In the title text Randall claims that in the programming language C the multiocular O () character, an exotic glyph variant of the Cyrillic letter O, is used to represent the bitwise version of the last operator Norxondor

gorgonax (presumably represents the non-bitwise version), fitting as the multiocular O is used to refer to "many-eyed seraphim" (angels) in some religious literature. Gorgons (beige or otherwise) have heads covered with snakes instead of hair, and so possess multiple eyes, the most famous was known as Medusa (she was depicted in 1608: Hoverboard). The character abstractly inspires ideas of great otherworldly demons like those of the Cthulhu mythos.

C is a low-level programming language, and as such, it has many operations that correspond to logical (i.e. bitwise) operations. These contrast with operations that work in a non-bitwise way. For example, "&&" is the non-bitwise "AND" operator that takes the operands as a whole, while "&" is the bitwise "AND" that combines the respective bits of its two inputs independently before spitting out the new single composite value the output bits represent. In non-bitwise operations, 0 always represents "FALSE", while any non-zero value means "TRUE" for inputs, and 1 is used to represent TRUE for outputs. Thus, "14 && 3" gives the result 1: TRUE AND TRUE -> TRUE. In the bitwise operation, using the same values, the decimal value 14 has the binary value 1110 and the decimal value 3 has the binary value 0011, and for this example we get:

#2498: Forest Walk

August 04, 2021



The only other person to walk by was a linguist back in the 80s, but she just spent a while dissecting the phrase 'help me down' before getting distracted by a squirrel and wandering off.

Explanation

Megan is walking through a wide landscape with Beret Guy who owns a big part of it. Megan is surprised that he owns such a big property, however, Beret Guy is known for his inexplicable businesses such as in 1493: Meeting and from 1032: Networking; we know he probably has enough resources to be able to buy it. Alternatively, he might have simply inherited it from his mom (see 502: Dark Flow), or may not understand the concept of owning it. Nevertheless, he walks here every day, and from the context of the comic, it seems pretty much no one else comes here.

They meet a rather disheveled-looking bearded man hanging from a parachute caught in a tree. The man shakes a stick at them and demands to be helped down to the ground. Beret Guy simply addresses him as "Mister Cooper" and asks if he promises to return the money he took. The man angrily refuses, and Beret Guy casually says he'll see him again tomorrow, suggesting that this conversation has become a daily routine. Megan asks if the man was D. B. Cooper, which Beret Guy immediately confirms. He then comments on an owl nest as another bit of "neat stuff" found on his land, suggesting that he finds Cooper's presence to be just another mildly interesting part of this land.

D. B. Cooper is the identity given to a man who hijacked a Boeing 727 aircraft in 1971. He collected a \$200,000 ransom (equivalent to \$1,250,000 in 2020) and famously

donned a parachute and jumped from the plane over the state of Washington. He was never seen or heard from again. Despite lengthy FBI investigations and nationwide publicity, the hijacker was never identified. A few thousand dollars of the ransom money was found in a river, nearly 10 years after the hijacking, but the remainder has never been recovered. The only things known about him are a police composite drawing and the name "Dan Cooper", under which he had purchased his airline ticket (he was called "D.B." as a result of a miscommunication with the media, and the name stuck).

The high-profile case followed by the never-solved mystery has led to a massive amount of speculation as to his identity, background, and what became of him. Many consider the most likely scenario to be that he didn't survive the parachute jump, and simply crashed somewhere that his body was never found. Others imagine that he escaped with the money and simply managed to evade capture. The comic is insinuating that, after leaping from the plane, he got entangled in a tree in Beret Guy's land and has been there ever since.

Uncanny situations are nothing new to Beret Guy since he possesses many strange powers. Hence, the concept of a famous criminal hanging from a tree for nearly 50 years doesn't seem any more interesting to him than an owl's nest. In keeping with the typical bizarre-ness of Beret Guy's life, it isn't explained how a man could survive for half a century hanging from a tree, why he'd choose to remain trapped there for his entire life rather than return money that he's in no position to spend, or why Beret

Guy wouldn't simply report his whereabouts to the police. All of these are simply accepted as unremarkable realities of life, for him. Randall already referenced D. B. Cooper a few times before this comic.

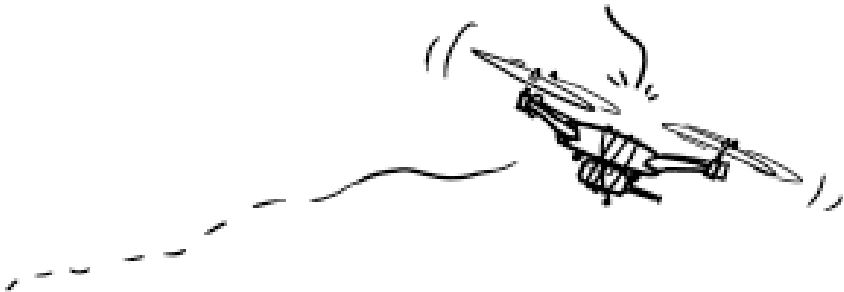
The title text may refer to the linguist from 2390: Linguists who is more interested in the linguistic nuances that people use than in actually responding to their call for assistance. It is not known how many others have walked through Beret Guy's land, in the interim, or whether it is their nature or the general aura from Beret Guy, but the linguist did not much more than ponder the phrase "help me down". Megan also seems in no particular hurry to intervene.

#2499: Abandonment Function

August 06, 2021

HI, I'M YOURS NOW!
PLEASE CHARGE ME!

HI, I'M YOURS NOW!
PLEASE CHARGE ME!



TECH TIP: IF YOU EVER GET TIRED OF A TOY DRONE, TIE THE CONTROLLER TO IT AND SET IT OUTSIDE. ITS ABANDONMENT FUNCTION WILL ACTIVATE AND IT WILL FIND A NEW HOME.

Remember to only adopt domesticated drones that specifically request it. It's illegal to collect wild ones under the Migratory Drone Treaty Act.

Explanation

This is another one of Randall's Tips, this time a Tech Tip.

Pet abandonment is a situation of concern among biological pets, and is part of the reason there are animal rescue organizations providing for adoption in most regions. Since drones are automated, they can be programmed to have an automatic abandonment function.

In reality, this "abandonment function" is the norm that things left outside homes are often considered gifts for any passersby who would like them. Hence, following the instructions in the webcomic may result in one's drone disappearing for a new owner, but not for the reason depicted.

With the drone responsible for flying to find its own new owner, one can possibly imagine it becoming more and more "fervent" as its charge runs down, to prevent the accumulation of derelict drones in the streets.

Triggering abandonment based on extended close proximity to the device's own controller could produce issues such as accidental activation, or malicious activation by a party who could send the proximity signal from a great distance, possibly to many drones at once, via software defined radio. It is, however, more likely that being left consciously uncontrolled for an extended

period is the actual trigger, with the attachment of the controller being more a direct courtesy to the next adoptive-owner, and/or preventing the loss of carrier signal that would instead activate whatever auto-homing (i.e. return-to-launch-point) behavior the more sophisticated drones may use if ever beyond their pre-programmed flight parameters.

The concept of there being "wild" vs "domesticated" drones rings again both of wildlife and pets, and of new intelligent software providing for drones acting on their own. In the latter case, protection for "wild" drones could imply many things about the role of artificial intelligence in society. Did we organize the wild drones to obey our laws, or are we protecting them in fear of being punished by their superior power? A foreign military drone could also be considered a wild drone.

But more likely Randall is imagining flocks of abandoned drones, fending for themselves, traveling distances as they survive off of seasonally-dependent charging resources. This is similar to the behavior of birds, which are protected (in the U.S.) by the real-world Migratory Bird Treaty Act of 1918. Aggressive flocks of drones was used in 1630: Quadcopter and drones has become a recurring theme on xkcd, where also training of drones as a pet has been the subject in 1881: Drone Training.

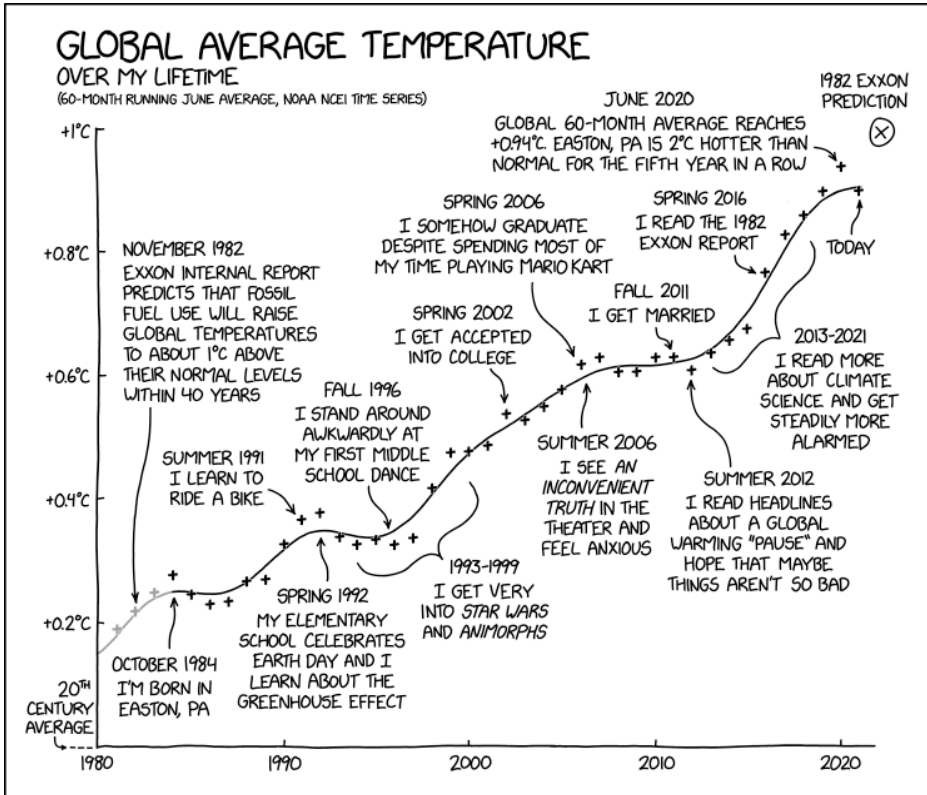
This idea of protecting drones is analogous to the anomaly that misbehaving drones have not been well tracked by law enforcement:

<https://observer.com/2020/01/drone-flock-mystery-baffling-authorities/> . If computer viruses continue to evolve, wild drones could indeed evolve too, as they are directed by software, but usually a human being or organization is considered to be somewhere at the helm (separately) of both computer viruses and drones.

The idea that a drone may choose of its own volition whether to find a new owner or join a wild flock is a little similar to the situation for abandoned pets.

#2500: Global Temperature Over My Lifetime

August 09, 2021



I was really impressed by the accuracy of some of the report's predictions about fossil fuel consumption. Then I realized, oh, right, of course.

Explanation

This is Randall Munroe in his role as a meticulous, conscientious presenter of scientific data. The activities shown in Randall's lifeline, whether learning to ride a bike or even getting married, pale into insignificance when the consequences of unprecedented global average temperature rise are understood and accepted. In particular, he shows that back in 1982, two years before Randall was born, Exxon wrote an internal report predicting the rise of global temperatures due to fossil fuel use, and 40 years later their prediction (shown as the X in a circle at the top-right) is being shown to be right on track. Unfortunately, that report was hidden and not seen until much later, and the world has been slow to respond with the urgency needed to reverse the damage being done to the planet.

The Wikipedia article [global temperature record](#) has some telling graphs to supplement Randall's. This one: [Global Average Temperature](#) is the global average temperature change for the modern era, since data started being collected regularly in 1850. This one: [2000 Year Temperature Comparison](#) reconstructs 2000 years of temperatures.

And this comic is a small segment of another comic: [1732: Earth Temperature Timeline](#).

The comic itself links to the referenced Exxon document about CO2 emissions.

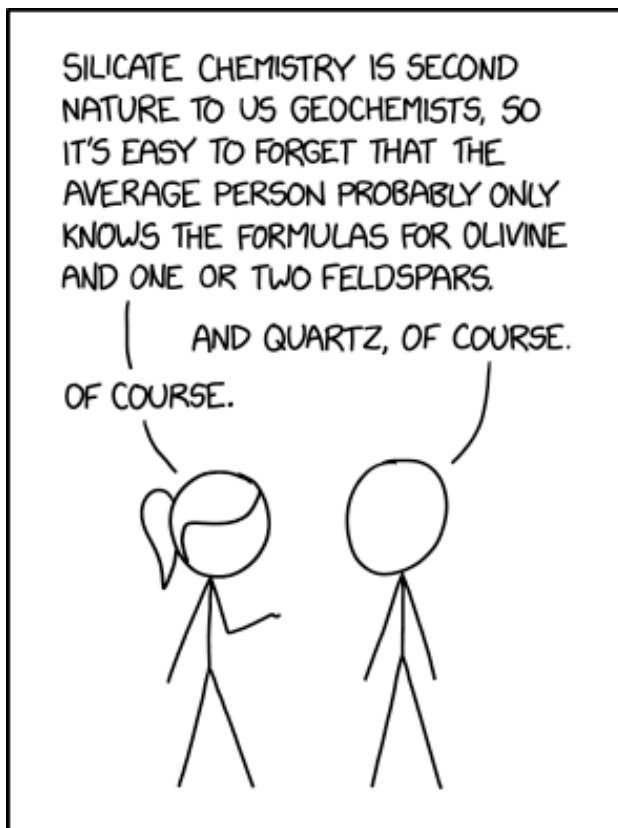
The comic was published on the same day that the U.N. Intergovernmental Panel on Climate Change released its 2021 Assessment Report

One of the entries is I somehow graduate despite spending most of my time playing Mario Kart. Mario Kart is a popular video game series developed by Nintendo, and has been a recurring theme on xkcd. Hewing close to the comic's timeline, 127: The Fast and the Furious, which contains an early Mario Kart joke, was released in July 2006.

The title text refers to the fact that Exxon, being a fossil fuel company, is likely to make better predictions on fossil fuel use as they are involved in fossil fuel production themselves.

#2501: Average Familiarity

August 11, 2021



EVEN WHEN THEY'RE TRYING TO COMPENSATE FOR IT, EXPERTS IN ANYTHING WILDLY OVERESTIMATE THE AVERAGE PERSON'S FAMILIARITY WITH THEIR FIELD.

How could anyone consider themselves a well-rounded adult without a basic understanding of silicate geochemistry? Silicates are everywhere! It's hard to throw a rock without throwing one!

Explanation

This comic claims that experts vastly overestimate how familiar other people are with their own field of study. As an example, Randall shows a conversation between Ponytail and Cueball as two geochemists specializing in silicate chemistry. Although the two scientists understand that the layman does not know all that they know about silicates, they are still under the impression that other people at least know the chemical makeup of olivine and some feldspars. Cueball also mentions quartz, an even simpler mineral taken for granted by Ponytail.

In truth, the average person can't be expected to know the chemical makeup of any arbitrarily-chosen substance reliably (or any material at all), if that average person's job and hobby do not involve chemistry — aside from the few that made their way into common knowledge, like NaCl for salt (sodium chloride or halite in mineral form), H₂O for water (facetiously known as dihydrogen monoxide, ice in mineral form), or CO₂ for carbon dioxide (while most people are more familiar with its gaseous form, it is also used in mineral form as dry ice), and may not even know the definition of "feldspar" beyond "a mineral", if at all.

It even goes so far as to initially gloss over the 'everyday' knowledge of quartz... until prompted by the slightly-less-overestimating partner in the conversation. Perhaps like a gardener forgetting to mention the lawn he maintains (along with the 'actual' plants in the borders or

vegetable patches), there seemed no need to include such a common mineral as a subject of silicate chemistry. Quartz is a basic silicon oxide (SiO_2) that many non-chemists have heard of because it is common and has a variety of uses, though they would not know its chemical structure. Quartz can be found as distinct large-scale crystals (probably obvious to the layman, as an ice-cube is in a drink) but also features as a hard-wearing micro-constituent of many rocks. Quartz is a major component of most sand (except for coral sands, which are calcium carbonates). Quartz crystals are sometimes made into jewelry and other decorative objects. Most modern clocks use the resonance frequency of quartz to keep time.

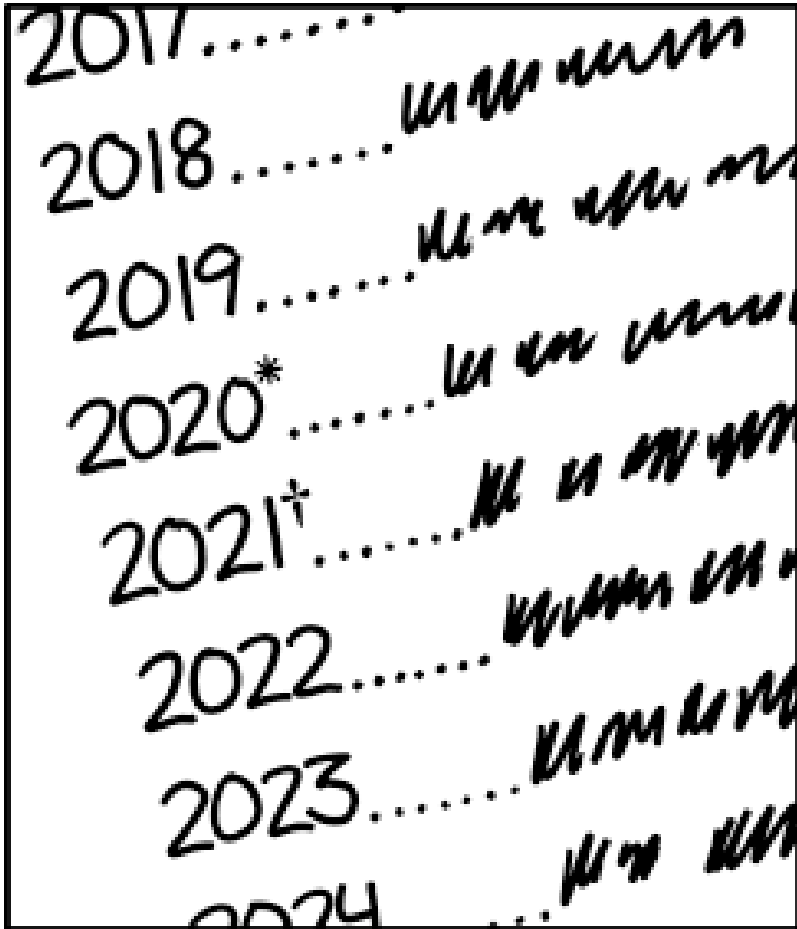
Minerals like feldspars and olivine generally exist as a continuum of varying chemical formulas, represented as a mixture of "endmembers" that have some pure composition. Feldspars are a category of aluminum-containing silicate minerals that account for the most of the rock in the earth's crust by mass. They are composed of a silicon-aluminum-oxygen lattice filled with sodium, potassium, or calcium ions. The major varieties are $\text{CaAl}_2\text{Si}_2\text{O}_8$ (anorthite), $\text{NaAlSi}_3\text{O}_8$ (albite), and KAlSi_3O_8 (potassium feldspar). Olivine is most notable as being the primary constituent of the upper mantle and commonly found in stony meteorites, and has the formula $\text{X}_2\text{+2SiO}_4$, where X is any iron or magnesium ion. The ends of the spectrum are Mg_2SiO_4 (forsterite) and Fe_2SiO_4 (fayalite).

In the title text the two geologists express belief that the

average person should be more familiar with silicates because of how ubiquitous they are. Their somewhat-exasperated statement plays on the phrase "you can't throw a rock without hitting one," a standard hyperbole about how common something is. Indeed, silicate rocks are extremely common on Earth — not only would a rock thrown in a random direction stand a decent chance of striking a silicate mineral rock, but the rock being thrown also has a very high chance of being a silicate mineral rock. With the exception of a few carbonate deposits, rocks found in large deposits on Earth's surface nearly all have silica in them, even extraterrestrial rocks. The Earth's crust is about 60% silica by weight.

#2502: Every Data Table

August 13, 2021



EVERY DATA TABLE FROM NOW ON

I'm hoping 2022 is relatively normal because I don't know what symbol comes after the asterisk and the dagger.

Explanation

This comic is another entry in a series of comics related to the COVID-19 pandemic.

It shows a future data table with one entry for each year from 2017 to 2024, so this table is made at least three years after publication of the comic (presuming it does not depict some form of advanced estimation of trends). The only discernible differences across the eight years are that two years have footnotes as in 2020* and 2021†, whereas the other six years have not.

Sometimes a symbol such as an asterisk (*) or a dagger (†, also called an obelus or obelisk) is used to denote an unusual entry in a table to be explained in a footnote with a matching symbol.

The COVID-19 pandemic has had a large impact on the entire world and one way this can be seen is through strange stats resulting from the effects of the pandemic, at least in 2020 and 2021, the years marked with footnote in the data table. Various statistics such as employment statistics, spending power, holiday miles, pet ownership, births (or at least conceptions), and—naturally—deaths may have been either grossly suppressed/increased for the majority of 2020, and for 2021 may have hardly recovered, partially recovered, renormalized, bounced back with a vengeance or be over-compensated for in the effort to catch up.

Thus Randall concludes that "every data table" will look like this one from now on, hence the title of the comic.

In the title text Randall states that he hopes 2022 is relatively normal. Comically, he doesn't mainly hope for this because he wants the COVID-19 pandemic to end, but rather because he doesn't know what footnote symbol to use after the asterisk and the dagger.

At the time of this comic's publication in August 2021, nothing was exactly back to normal and proper recovery or the resulting compensatory readjustment may not have concluded in time for 2022 to reflect the trends expected based upon pre-2020 figures, and the additional further years that future statistics will record. The point is moot, however, because in February 2022 Russia invaded Ukraine and (directly or indirectly) triggered various humanitarian, economic, and political crises around the world. By 2023 the war was still a source of global instability and any hopes of normalization are extremely premature.

Common symbols that are used after the asterisk and dagger include the double dagger (§), the section symbol/silcrow (§), the parallel/double-pipe (||) and the paragraph symbol/pilcrow (¶). Alternately one could use multiple symbols (such as †† or ***) or superscript numbers (¹, ², ³ ...).

In Randall's book *What if?*, he uses numbered superscript footnotes. In *What if?* 2, he uses § and §. The first time this happens is on page 121. Given the time this

comic was published (aug 2021) and the time the book released (sept 2022), it's not impossible that writing that page is what inspired this very comic.

Unrelated to the usage as English footnote characters, the asterisk and dagger symbol are used in German mainly as the shorthand "genealogic signs" to express "born" and "died" respectively (e.g. in encyclopaedias, as the German terms geboren and gestorben are three-syllable words and would need to be shortened, but start with the same two letters), so a person that is 2020(*) and 2021(†) would have been alive for only about a year, depending on the months. This symbology is also used on some tomb stones. An optimistic view is the "birth" and "death" of the coronavirus SARS-CoV-2, which would also understandably result in uncertainty on the next symbol in this order, for 2022. Pessimists in this context might suggest to use ∞ , which is the symbol for infinity.

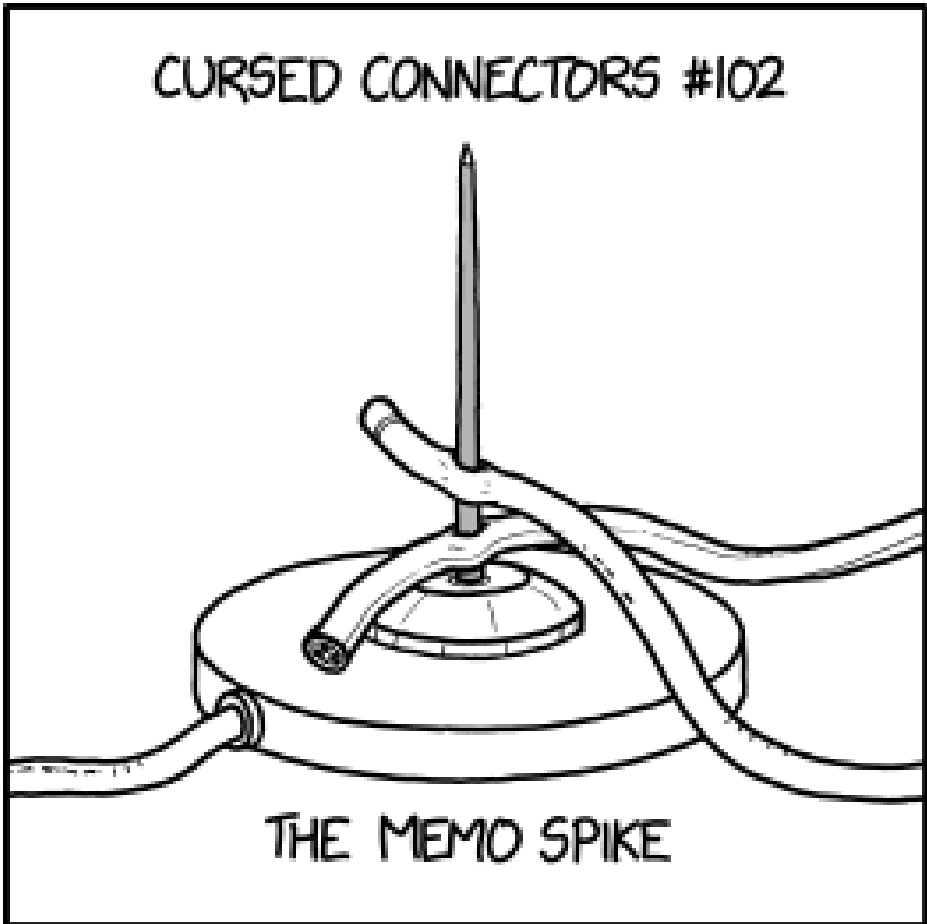
Similarly, in biology, an asterisk marks a species (or genus, etc...) that is possibly extinct and a dagger is used to note the possible extinction. (Double asterisks indicate taxa believed to be extinct in the wild but known to be extant in cultivation). This of course does not fit well with SARS-CoV-2, which is not close to extinction.

Randall seems not to have noticed the potential monkey's paw nature of his wish. "Relative" requires a comparison between things. It could be that the whole fall-out of the pandemic becomes the new normal, and future years have no necessity to use symbols to explain how those years come to be like everyone knows they are,

while dates before 2020 will be entirely understood as the old normal. Only 2020 and 2021 may need contextual clarifying, due to their nature as a transition from the old normal to the new normal.

#2503: Memo Spike Connector

August 16, 2021



Backward-compatible with many existing cables, and can connect directly to phones or tablets if you press them down hard enough.

Explanation

This is the third installment in the series of Cursed Connectors and presents Cursed Connectors #102: The Memo Spike. It follows 2495: Universal Seat Belt (#65) released three weeks before and was followed 9 days later by 2507: USV-C (#280).

The comic depicts a large metal spike with a wire coming from the base. The spike stabs through two other wires, thus creating an electrical connection between the three. As the name suggests, the spike resembles a stationery spindle, colloquially known as a spike, called a Memo Spike here by Randall. However, unlike normal spindles, this one has a cable of some kind coming out of it, suggesting this is a hub of some sort.

Spindles are used to temporarily hold paper by "spindling" or impaling the paper onto the spike (as depicted in the comic). They're most known for their use in restaurants as a way to hold bills that have been paid, or traditionally in offices that work with many bits of paper, e.g. with invoices in a finance department or hardcopy in newspaper editing, to prevent accidental disturbance/shuffling, at the expense of a small puncture mark in each sheet so impaled. (This could cause errors in papers with punch-holes that are meant to be read by machines, hence the admonition against "folding, spindling, and mutilating".) In the latter context, the editor might put all the rejected stories onto a spike (rather than into a wastebasket) to prevent them going

astray, and this might be the source of the term 'spiked'.

The joke of the comic is while any number of non-destructive connection standards exist, a large spike can provide much of the same results: a conductive object that retains a connection of multiple wires in a way that allows electricity to pass through. Indeed, in the early days of Ethernet, vampire taps were used, essentially spikes that bit into a cable to establish a new branch in the network. Another type of connection which involves piercing the wire is a punch-down block, a type of insulation-displacement connector, where one or more wires are pushed into a cutting channel instead of onto a spike.

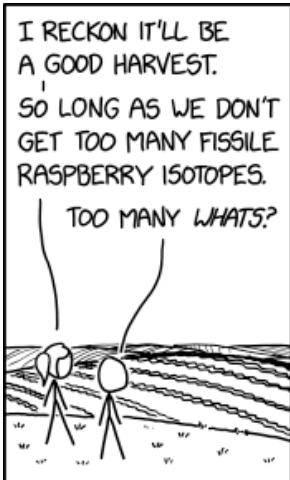
Depending on the type of cable it is also likely to create a short circuit, e.g. by connecting both strands of a twisted pair of strands in a typical Ethernet cable, or the central wire and the sheath of a coaxial cable. In an enterprise environment, this could even happen on a PoE-Connection, which actually carry more noticeable amounts of power (up to 25.5W). Even if this is avoided, the single spike may be large enough to mechanically sever a random subset of the finer strands that exist within a multicore cable such as is commonly in use today.

The title text takes this a bit further. It says that it is backwards compatible with many existing cables. This means any cable large enough to be impaled by the spike could be used. Needless to say it will likely not work anyway. It also continues by saying that phones and

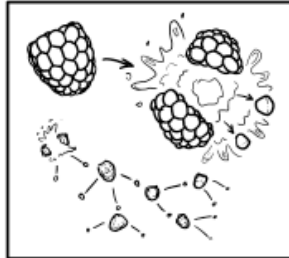
tablets can also be connected using this method if you press them down hard enough over the spike. Thus if you actually manage to make the spike penetrate the device's coverings to reach the electrical parts, then there is a connection. The implication is that any device or cable can be connected to any other device or cable as a form of universal adapter/splitter/combiner across arbitrary hardware and communications/power standards. In reality, this could be even more dangerous and will surely destroy the phone/tablet either directly or by overloading their cable connection.[citation needed] Also be careful not to impale your hand while trying to push the spike through your tablet's screen.

#2504: Fissile Raspberry Isotopes

August 18, 2021



IF A RASPBERRY BREAKS IN HALF, IT RELEASES FRAGMENTS WHICH CAN CAUSE MORE SPLITS. WITHIN SECONDS YOU'VE LOST THE WHOLE CROP.



LUCKILY, THE BERRIES ARE BOUND BY FRESH RASPBERRY PIE MESONS.

I HOPE THEY HOLD. IT'S MY GRANDMA'S RECIPE. THEY'LL HOLD.



Grandma's shelf-stable blackberry pie meson recipe was a huge seller until her farm was shut down by a joint FDA/NRC investigation.

Explanation

Ponytail is admiring her raspberry fields telling Cueball she expects a good harvest...if they do not get too many fissile raspberry isotopes. To this, Cueball has to ask Too many whats?

The comic is thus a joking analogy to nuclear chain reactions, in which the fission (splitting in two) of one atomic nucleus releases neutrons, which then strike other nuclei and cause them in turn to fission, releasing more neutrons. This chain reaction releases a great deal of energy and is what makes possible both nuclear power and nuclear bombs.

A fissile isotope, such as uranium-235, is one that is sufficiently large and unstable to undergo such a chain reaction, as opposed to the more common and less unstable uranium-238. Ponytail fear that her raspberries have too many unstable isotopes so that her fields risk undergoing a similar fission-driven chain reaction. This chain reaction is depicted in the second panel, and she explains that if this happens the entire crop may be gone in seconds. It sounds like this is only dangerous for her economy, i.e. all the berries destroyed, but not a runaway explosion that destroys her field and any living thing nearby.

In real life, raspberries don't undergo such chain reactions.[citation needed] As an aggregate fruit, raspberries (as well as blackberries mentioned in the title

text) resemble common depictions of atomic nuclei, with each drupelet corresponding to a nucleon (proton or neutron), which is probably why they are the subject of the comic. (The actual "appearance" of atomic nuclei, in contrast to the common depictions, is complicated by Heisenbergian uncertainty, quantum effects, and strong nuclear force interactions.) Perhaps these raspberries are byproducts of the experiments depicted in 1949: Fruit Collider.

This comic is also a pun on "pi mesons" or pions, subatomic particles that transmit the strong nuclear force, and the similarity in name to a pie, the food type, as in a raspberry pie. The transmission of the strong nuclear force happens most importantly in the atomic nucleus and is responsible for keeping the nucleus intact, i.e., preventing it from undergoing fission despite the strong repulsive electromagnetic force present from all the positively-charged protons.

Raspberry pies (and pie mesons of such) are not to be confused with Raspberry Pi, a very popular microcontroller widely used for hobbyist or educational projects.

Ponytail claims that her berries are protected (bound) by fresh raspberry pie mesons. Cueball states he hopes they hold, but Ponytail is confident as these pies are made from her grandma's recipe, i.e., it is actually a fresh pie made from the berries. The faith in the pie recipe being able to impede the danger references the convention of "Just like Grandma used to make", nostalgia for an

infallible cookery ancestor, in this case a hallowed family recipe that acts to mitigate any budding 'berry' chain-reaction. Grandma's baking is not always so fondly remembered and, in this case, it could be some (in)famous inertness and solidity to the product that is reassuring, not any form of culinary excellence.

The title text mentions that the grandma's "blackberry pie meson" recipe was a huge seller, but that then the farm was shut down by a joint FDA/NRC investigation. This refers to the Food and Drug Administration (FDA) and the Nuclear Regulatory Commission (NRC). The FDA is responsible for the regulation and inspection of food in the U.S., and the NRC for the regulation and inspection of nuclear facilities and materials. A hypothetical "blackberry pie meson" might well run afoul of both, being both nuclear and therefore subject to NRC regulations and permitting requirements, and unhealthy to eat and thus violating FDA rules. This could in addition also violate the FDA's rules on radiation emitting products. One might be able to imagine the FDA discovering that the blackberry pies are functioning to contain a nuclear chain reaction, and calling in the NRC to consult. The FDA took a similarly incongruous interest in physics in the title text of 2216: Percent Milkfat.

It is mentioned that the pies were shelf stable, which means it can last a long time without being in a refrigerator. This may be because of its innate radioactivity keeping it free from germs. This may also explain why they were shut down by both the

above-mentioned agencies. The word "stable" also describes atoms, and therefore substances, that do not spontaneously undergo nuclear decay, though a stable isotope may (eventually) result directly from the decay of an unstable one.

#2505: News Story Reaction

August 20, 2021

DEVASTATED TO HEAR THAT A PACK
OF WILD DOGS GOT INTO THE LOUVRE
AND SHREDDED THE MONA LISA.

WHAT A LOSS FOR HUMANITY.

MY FIRST KISS WAS IN THE AISLE OF
A J.C. PENNY THAT HAD A POSTER
OF THE MONA LISA ON THE WALL, SO
THIS IS HITTING ME ESPECIALLY HARD.



SOMETIMES I HAVE TO REMIND MYSELF NOT
TO MAKE EVERY NEWS STORY ABOUT ME.

Unless the next line is, "After we broke up, she blamed the painting and spent years planning her revenge, so my sorrow is mixed with relief that the dogs at least denied her that triumph."

Explanation

In this comic, Cueball is at his computer, likely typing a comment after reading a shocking news story where the Mona Lisa has been attacked and shredded by a pack of wild dogs. The Mona Lisa is one of the most famous paintings in human history. At the time of this comic, the Mona Lisa has not been attacked and is unlikely to be shredded in this circumstance at least by dogs as it is painted on wood, rather than canvas. In addition, the Mona Lisa is protected by bulletproof glass, so it is highly unlikely that a pack of wild dogs could shred the Mona Lisa alone without human assistance, even if you disregard the fact that it is painted on wood.

At the beginning of his comment, Cueball describes his reaction and disappointment about the event, describing the event as "a loss for humanity." Cueball is then reminded of his first kiss, which occurred inside of a JCPenney, where a picture of the Mona Lisa hung on one of its walls. He adds this to his comment, explaining that this is why the news hits him hard. However, his story has almost no relation to the Mona Lisa, other than that the picture was at the scene as well as being unnecessary.

After posting the comment, Cueball reflects on this and mentions that not every news story is, or needs to be, about himself.

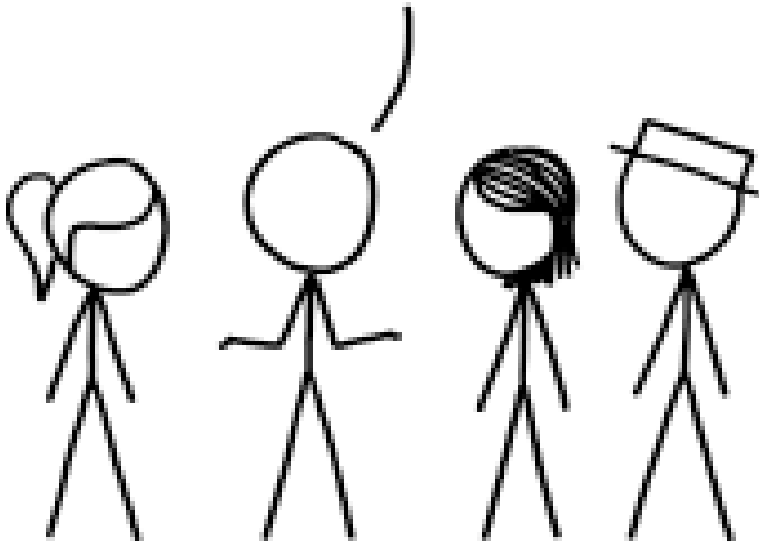
The title text describes an exception to this, where his

experience IS directly related to the affected painting, as his ex seemingly planned to get revenge on the painting itself. The title text suggests that the dogs destroyed the painting before Cueball's ex could do so. (But perhaps it could be that she let the dogs in, and so this extra information could lead to the police finding the person who was responsible.)

#2506: Projecting

August 23, 2021

LIKE A LOT OF YOU, I
HAVE A REAL PROBLEM
WITH PROJECTION.



This is something we all need to work on, but especially you all.

Explanation

Serious explanation[edit]

In this comic, Cueball expresses his difficulty with psychological projection. Projection is taking qualities of the self and attributing these qualities to others.

Cueball actually admits he has a real problem with projecting, but while doing so, he is seemingly oblivious to the fact, that he is stating this in a way that projects his self-identified difficulty upon his friends: Ponytail, Megan and White Hat. Of course, this could also just be a joke made by Cueball, as it is the joke in the comic. On the other hand, Cueball and Randall have serious issues with social interactions, and this could just be another example of such a problem.

In the title text, Cueball continues his projections, stating that this is something we all need to work on. So he continues to believe that all the others have the same problem, not just a lot of them as in his original statement, which left the possibility that not all of them had this issue. In the end, he also tops it by saying but especially you all indicating that he imagines his own case is a less serious issue of projection than that he actually projects the others as having.

Alternately, the phrase having a real problem with projection usually means the person speaks quietly, their voice doesn't carry very far, particularly in acting and public speaking environments. Someone with difficulty projecting wouldn't be heard by people in the back row, or perhaps even halfway into the audience (depending how much difficulty they have). This comic is

notably smaller than the average xkcd comic, making it the visual / comic equivalent to not projecting. Just as a non-projecting voice cannot be heard very far away, this comic cannot be seen very far away (in either case, not as far as usual). Under this interpretation, the title text is referencing that his audience is also not projecting, they're just as small as he is.

Jokes[edit]

Alternatively, Cueball expresses his difficulty with complex numbers. There exists a common projection between the complex and reals, but it may not be clear to him about which method to use or how to do it. If he is projecting onto the real part of the complex line, then his issue is a many-to-one problem, which explains why it is everyone else's problem as well.

An alternative perspective might be that the characters, as stick figures, are represented as two dimensional projections of three dimensional objects, and this projection has an issue that depth information is not preserved, so for example, it isn't clear whether cueball is facing towards us or away from us. As his arms are not foreshortened by the projection, this indicates that he is standing in an unnatural pose, so the fact that he says that especially the other characters have a problem with projection would be a good example of psychological projection.

A further alternative read could be that Cueball is acting as the Randall surrogate, noting that the other characters are projections of Randall's conscious and subconscious self. The title text could then be read as either directed to those aspects as expressed as characters within the comic, or directed to the reader, who also has things to work on.

A different meaning of the term "Projecting" is seen in the fields of public speaking and drama, being the way that a person clearly uses their voice to address an audience. If Cueball is not projecting well, then the characters listening to him may ignore him.

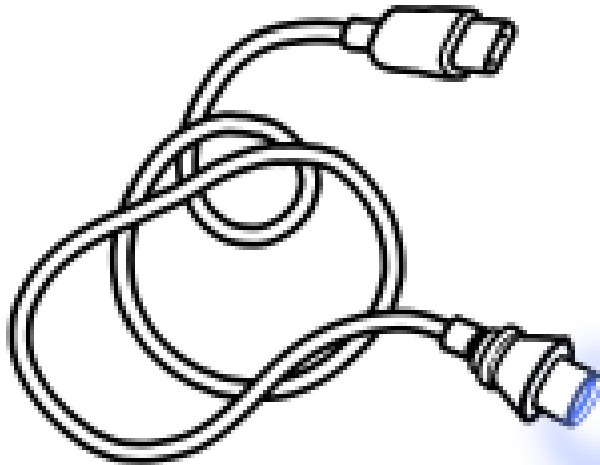
Projection is an ongoing issue. People from disparate communities can experience this all the time, where one person assumes out of habit that the other person has the traits of their community. On the end of the spectrum, projection can be completely delusional, as the comic hints at. It would make sense for that be more common for people who attend less to where others are at, such as introverted or powerful people, two groups that experienced engineers can land in.

It is also possible that Cueball is addressing the portion of readers who feel the need to project onto Randall their own desire (and meticulousness in analytical searching) for layers upon layers of hidden meaning in xkcd comics. The assumption that he has stuffed several different obscure punchlines into the one sentence of a single-panel comic is, despite the layered punchlines in some other comics, quite a stretch. Randall may be suggesting that such projections from readers onto him are problematic because they cause comic explanation pages to be filled with rambling speculation that can make the explanation of the actual joke harder to understand.

#2507: USV-C

August 25, 2021

CURSED CONNECTORS #280



USB-C TO UV-C

Ultra-Serial Violet C light is unpolarized, so you don't have to flip the polarizing filter over when you get the orientation wrong the first time.

Explanation

This is the fourth installment in the series of Cursed Connectors and presents Cursed Connectors #280: USB-C to UV-C. It follows 2503: Memo Spike Connector (#102) released 9 days before but was first followed just a bit more than half a year later by 2589: Outlet Denier (#78).

This comic depicts a cable that converts from USB-C (at the top of the picture) to UV-C (at the bottom).

USB-C is a rotationally symmetrical Universal Serial Bus (USB) connector. UV-C is a range of ultraviolet light with wavelengths between 100 and 280 nm. This is often used as a germicide, so this comic may also be related to the COVID-19 pandemic. The U.S. Food and Drug Administration (FDA) has an infosheet with information about these devices and COVID-19. And the connector number (280) is likely chosen because it is the boundary between UV-C and UV-B in nanometres.

Similar cables actually exist, with a USB port at one end to power a small (usually visible light) lamp at the other. A cable with a UV-C lamp could, as noted above, be useful for disinfecting surfaces or verifying banknotes [actual citation needed]. However, the depicted design would be problematic because it would expose the user's skin and eyes to harmful ultraviolet radiation, unless it's specifically Far-UVC (222nm, safe for human skin and eyes).

Unless there is more to the UV-C end than indicated, the cable seems not to have use in bidirectional communication (even to confirm that it is plugged in or shone upon some suitable optical transceiver) so in any data transfer situation it could be a limited-range broadcast-only system at best - which has its uses in certain niche cases.

The title text mentions that the UV-C is unpolarized. This is a pun with two uses of the term polarized. When referring to a connector 'polarization', or absence of it, it means that USB-C does not force you to use a single correct orientation when using it, i.e. you don't have to turn it "right-side-up" like USB-A or USB-micro.

It also refers to the use of a polarizing filter which takes unpolarized light waves and blocks out the waves that are not oriented in the same direction. These are used in sunglasses and photography to eliminate glare and enhance the image. These filters do need to be oriented in a specific direction in order to have the desired effect of passing/blocking a given polarization, perhaps to separate two perpendicularly orientated 'channels' that need to be unmixed exactly knowing the respective orientation of the two signals (or exactly 180° out, which is what USB-C effectively allows for at present).

The light could also have been circularly polarized, which allows 'left' and 'right' rotating polarizations to simultaneously carry separate signals, but not require the same strict orientation to operate properly, at all, so long as arbitrary mirrors are not involved at any stage of the

optical path. Regardless, the implication here is that there is no deliberate rationalization of the light to contend with, anyway, which seems to be just making a positive point out of a potentially lost opportunity to double any intended signal bandwidth. The name "Ultra-Serial Violet..." could be read as consciously eschewing all attempts at parallelism, including talkback.

#2508: Circumappendiceal Somectomy

August 27, 2021

NORMALLY WE WOULD REMOVE
YOUR APPENDIX FROM YOUR BODY.
BUT THANKS TO NEW SURGICAL
TECHNIQUES, WE'RE NOW ABLE
TO REMOVE YOUR ENTIRE BODY
FROM AROUND YOUR APPENDIX!



Some personal news: After treating my first case a few years ago with antibiotics, I can report that I have now had appendicitis for the second and--unless something extremely unexpected happened with the surgery--final

time.

Explanation

In normal medicine, appendectomy is the surgical removal of an appendix. The purpose of the appendix is not fully understood, believed to be a reservoir for a human's gut microbiome. However if an appendix is swelling, it comes with risk of bursting and causing massive damage through internal bleeding and septic bacterial infection. In such cases the appendix may be partially removed through surgery.

Breaking down the comic's title: circum- means "around," -appendiceal means "the appendix," som(a)- means "the body," and -ectomy means "removal." Therefore, a circumappendiceal somectomy would be "a removal of the body from around the appendix." This appears to be the procedure that the doctor in the comic is describing.

The joke is that such a procedure is functionally identical to a typical appendectomy, the removal of the appendix from the body - just viewed from a different perspective. It humorously implies that the entire body of the patient is the problematic part to be removed, leaving the appendix behind. It should be noted, though, that the procedure is identical only if it's done without disrupting the integrity of the body. There are situations in which an essential part is removed from a damaged or unimportant system by dismantling the system, piece by piece, leaving the part behind. Obviously, this would not be an advisable method for treating appendicitis.[citation

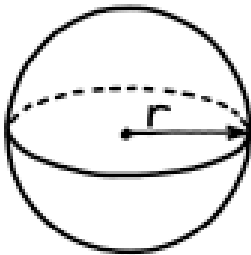
needed]

The title text provides personal insight into the comic. It appears Randall has gotten appendicitis before, which may have been the inspiration of 2147: Appendicitis and was treated using antibiotics instead of surgery. However, his appendix became inflamed again, and this time it was removed. Randall's experience is not uncommon, as a 2020 study found that nearly 40% of patients treated with antibiotics for appendicitis required an appendectomy for recurrent appendicitis within 7 years. However, this should be the final time, as it is unlikely to get appendicitis without an appendix.[citation needed] However, he does not rule out the possibility that something "extremely unexpected" happened during the surgery which could cause him to suffer from appendicitis again. Possible candidates for such an extremely unexpected event could include the surgeon faking the removal of Randall's appendix and leaving it intact, or removing only part of it, removing Randall's appendix but transplanting someone else's appendix into him instead, or even the appendix's spontaneous regeneration. While most of these possibilities are absurd, stump appendicitis, in which appendicitis occurs in remnant of the appendix that remains after surgery really does occur in 1 in 50,000 cases according to the article Appendicitis after appendicectomy - NCBI.

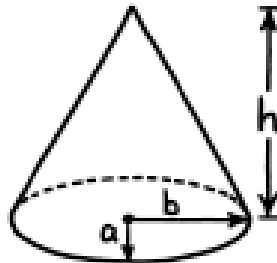
#2509: Useful Geometry Formulas

August 30, 2021

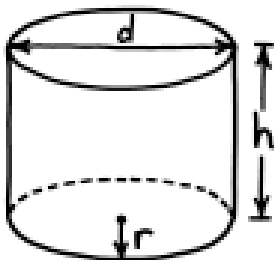
USEFUL GEOMETRY FORMULAS



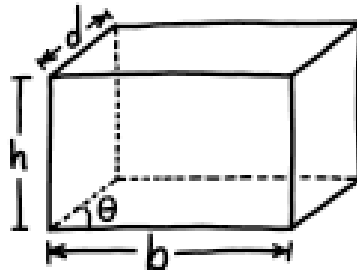
$$A = \pi r^2$$



$$A = \frac{1}{2} \pi a b + b h$$



$$A = d \left(\frac{\pi r}{2} + h \right)$$



$$A = b h + d (b \sin \theta + h \cos \theta)$$

Geometry textbooks always try to trick you by adding decorative stripes and dotted lines.

Explanation

This comic showcases area formulas for the areas of four two-dimensional geometric shapes which each have extra dotted and/or solid lines making them look like illustrations for 3-dimensional objects. The first, a simple equation for the area of a circle, the second an equation for the area of a triangle with a semi-elliptic base, the third an equation for the area of a rectangle with an elliptical base and top, and the fourth an equation for the area of a hexagon consisting of two opposing right-angled corners and two parallel diagonal lines connecting their sides. In each case, only the area formed by the outline of each shape is calculated.

Similar illustrations are commonly found in geometry textbooks, which are used to depict three-dimensional figures on a two-dimensional page. They commonly make use of slanted lines to indicate edges receding into the distance and dashed lines to indicate an edge occluded by nearer parts of the solid. The joke is that the formulae given here are for the area of each two-dimensional shape within its outer solid lines, not for the surface area or volume of the illustrated 3D object (as would be shown in the geometry textbook). The title text continues the joke by claiming that the dotted lines are simply decorative.

The illustrations depict the following plane or solid figures, depending on the interpretation.

This illustration is commonly used to depict a three-dimensional sphere, with the ellipse representing a "horizontal" or axial cross-section through the center; the solid lower half of the ellipse represents the "front" of the circumference of this cross-section, while the dotted upper half represents the "back" of the same section, which would be occluded from view if this were a solid shape.

The radius of the circle, from the center to the right edge where it meets the ellipse, is labeled 'r'. In a textbook diagram of a sphere, the radius might be instead labeled with a diagonal line from the center to a different point on the ellipse, implying the generality that all points on that cross-section, and indeed on the whole spherical surface, are at the same radius from the center. However, this line would be shorter on the page than the actual radius, making it useless for the formula of the area of the 2D outer shape.

The area of the 2D shape on the page is the area of the circle, which is $A = \pi r^2$. This is captioned below the figure.

Coincidentally the area of the horizontal cross-section of the 3D sphere, as depicted by the ellipse, is also πr^2 , and a reader familiar with such diagrams might initially assume that this is what was meant. However, this does not extend to the other figures.

The 3D sphere commonly depicted by this drawing would have a volume of $\frac{4}{3} \pi r^3$ and a surface area of

$4\pi r^2$.

This illustration is commonly used to depict a three-dimensional right circular cone, with the lower half of the ellipse representing the "front edge" of the bottom surface, and the upper half representing the occluded "back edge". However such drawings would usually not use both 'a' and 'b' to describe the radius of the base of the cone, which is drawn as an ellipse due to foreshortening. Alternatively, the drawing could depict a right elliptical cone.

Randall approximates the area of the 2D shape on the page as the sum of the area of the triangle formed by the major axis of the ellipse and the two lines, and half of the area of the ellipse ($\pi/2 ab$) since most of the upper half of the ellipse overlaps the triangle. The equation for this area is $A = 1/2 \pi ab + bh$. This is captioned below the figure.

The actual area of a picture of a cone is not Randall's approximation, because the sides connect at the points on the ellipse where they can spread widest and form tangents to the ellipse, and such points are a little higher than those which define the major axis. This is most obvious in cases when h is only a little larger than a . The area can be computed to be exactly $A = b (a \arccos(-a/h)) + \sqrt{(h^2 - a^2)}$.

The 3D right circular cone commonly depicted by this drawing would have a volume of $\pi r^2 h / 3$ where $r = a = b$. The area of the "lower" surface would be πr^2 , while the

surface area of the upper conical surface would be $\pi r \sqrt{h^2 + r^2}$. Neither of these areas can correspond with the caption in the comic, nor does the total surface area (the sum of these two).

If we do not assume that $a = b$, this drawing could also depict a right elliptic cone. The volume of the elliptic cone would be $\pi/3 abh$. The area of the lower surface would be πab and the area of the curved upper surface would be $2a \int_0^1 \sqrt{(b^2 + h^2)(t^2 - 1) - b^2(a^2 + h^2 t^2)/a^2(t^2 - 1)(b^2 + h^2)} dt$.

This illustration is commonly used to depict a 3D cylinder or right circular prism. In this case, the upper ellipse represents the "visible" part of the top circular surface, with its "depth" shorter than its "width" due to foreshortening, and the lower part of the lower ellipse represents the "front" edge of the lower surface; the dotted half of the lower ellipse represents the occluded "back" edge of the lower surface.

To add to the confusion, the upper ellipse has its major axis labeled 'd' which usually denotes the diameter of a circular surface, while the lower ellipse has its semiminor axis labeled 'r' which similarly denotes a radius, even though the ellipses drawn have neither diameter nor radius. The 'h' denoting height is also used for both rectangles and solid objects. While 'd' in this case is required for the area calculation of the 2D shape, in textbooks only 'r' may be marked and the arrow may be offset at a diagonal rather than in line with any figurative

axis, to imply its applicability to any angle of radius.

The non-overlapping parts of the 2D shape are composed of the rectangle formed by the major axes of the two ellipses and the vertical lines, plus half of the top ellipse and half of the bottom ellipse. The area of the rectangle is dh , and the area of an ellipse with semimajor axis $d/2$ and semiminor axis r is $\pi rd/2$. The total area is $A = d(\pi r/2 + h)$, which is captioned below the figure.

A 3D right circular prism (cylinder) would have a volume of $\pi r^2 h$ and a surface area of $2\pi r^2 + \pi dh$, or $2\pi r(r + h)$ since in this case $d = 2r$. The area of each flat surface would be πr^2 . If we do not assume $d = 2r$, then the lateral surface area of the right elliptic cylinder is $4h \int_0^1 \sqrt{(1 - t^2)(1 - 4r^2/d^2)/1 - t^2} dt$. The volume is $\pi/2 r dh$.

This illustration is commonly used to depict a rectangular prism, with 'b' denoting the 'breadth', 'd' the 'depth' and 'h' the 'height'. However, the labeled angle θ , which is necessary for the area calculation of the 2D shape, would not normally be used in a diagram of a rectangular prism, as all angles are assumed to be right angles. A rhomboidal prism could be accurately described by this diagram with the assumption that the 'base' parallelogram is perpendicular to the 'front' and that the only non-right angle is θ . In that case 'd' would not accurately describe the depth of the solid, which would be $d \sin \theta$.

The area of the 2D shape comprises the rectangle at the lower left, the parallelogram above it, and the

parallelogram on the right. The area of the rectangle representing the front face of the prism is bh . The area of the upper parallelogram is $db \sin \theta$. The area of the right parallelogram is $dh \cos \theta$. The equation for this area is $A = bh + d(b \sin \theta + h \cos \theta)$ as is given below the figure.

The surface area of the prism would be $2bh + 2db \sin \theta + 2dh$. The volume is $b dh \sin \theta$. Assuming a 3D shape, θ can be artificially altered by the projection; the assumption could be made that θ is 90 degrees, and $\sin \theta$ is 1 (and therefore can be eliminated from the formulas), but since θ is marked, such an assumption might not be valid.

In the history of the development of computer-generated 3D graphics, calculations of the apparent visual area taken up by the projection of a volume may have been useful in occlusion-like optimizations, where each drawn pixel may be passed through many fragment shaders.

#2510: Modern Tools

September 01, 2021



PEOPLE OFTEN USE ANCIENT TOOLS
AND UIs TO DEVELOP MODERN
CUTTING-EDGE TECHNOLOGY, BUT
I DO IT THE OTHER WAY AROUND.

I tried to train an AI to repair my Python environment but it kept giving up and deleting itself.

Explanation

Cueball tells White Hat how he has trained a neural net to generate mostly valid Makefiles.

This is the file type that Make searches for. In software development, Make is a build automation tool that automatically builds executable programs and libraries from source code by reading files called Makefiles which specify how to derive the target program. (See 2173: Trained a Neural Net). Make is a very old tool, having first appeared in 1976.

Then Cueball continues to tell that he next will train it to distinguish between Bash and Zsh.

Bash and Zsh are two command line interfaces for Unix-like OSes. The way to execute commands is almost identical, making detecting a script that contains a mixed syntax nearly impossible. This was previously referenced in 1678: Recent Searches. Bash and Zsh are also old tools, having come out in 1989 and 1990 respectively.

A human-designed 'random Makefile'-maker might have been written with this explicit choice amongst the earlier decisions in the generation process, but an AI might be assumed to have started (many, many generations ago) with something close to utter nonsense and painstakingly reached the stage of (mostly!) valid files along the way. Some might say that the differentiation training would have been better added at another point in the lengthy

process.

On top of that, the current (mostly valid) results may even be polyglot and/or shell-agnostic. Dependant upon the fitness tests in use, many other \$SHELL-choices and Makefile styles may have been coevolved as valid (if rarer) subgenus of outputs, such as a command.com-based makefile.

In the caption it states that Cueball is using modern tools to make ancient technology, as opposed to other people who use ancient tools and UIs (User interface) to develop Modern Tools.

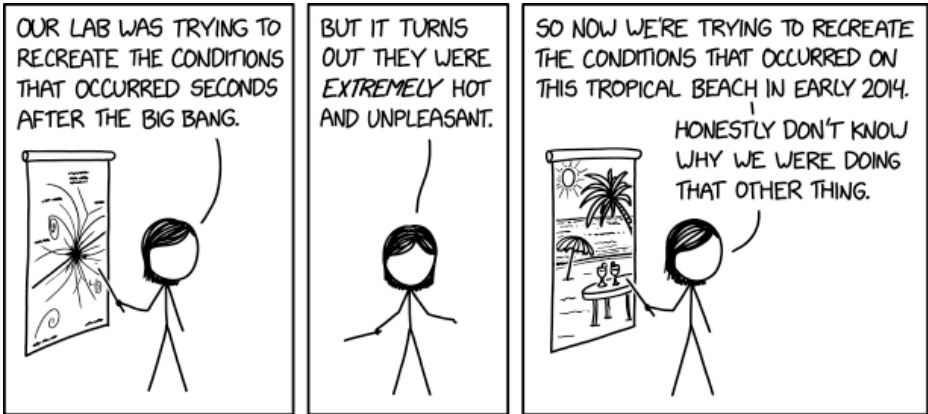
In the title text Randall states that he tried to train an AI (Artificial intelligence) to repair his horribly broken Python environment. But the AI kept giving up and deleting itself. The joke partly relates to when it or is not appropriate to personify goal-driven processes. In the study of alignment of artificial intelligence, it is common to consider AIs finding ways to meet the tasks they are given that are highly unexpected, and then developing into an apocalypse. A common unexpected solution encountered in research is that the agent finds a way to disable itself as more efficient to meet its reward parameters than anything else it discovers, and then learns to repeatedly do so. The AI might be so intelligent that it had developed critical 'personal' opinions that led it to be so intellectually appalled by the task, or else just found it impossible to fix the Python environment and therefore justify its own existence, that it had no other recourse but to commit a form of suicide because

Cueball's code was that bad (which is a recurring theme for Cueball). Python has been a recurring subject as has Programming and Artificial Intelligence.

The main joke is that Cueball is using cutting-edge tools to develop very old technologies, which is perhaps only useful if one is pursuing hobbies in conflict with a differing AI addiction. As the caption implies, it is much more common for people to use fundamental and well-established tools as the toolchain or building blocks of modern technology. A concrete example of this is writing scripts using decades-old Bash to automatically set up a significantly newer (2014) technology called Kubernetes.

#2511: Recreate the Conditions

September 03, 2021



We've almost finished constructing the pia collider.

Explanation

Scientists recreate conditions of things to gain scientific knowledge on a topic to better be able to observe why or how things happen. This could be done by making miniature versions of events and simulating events using safe methods.

In this comic, Megan's lab discovered that the conditions during the seconds after the Big Bang were extremely hot and unpleasant. They have thus decided to attempt to recreate the conditions of a tropical beach in 2014 instead (7 years prior to when this comic was released). Here, the joke is that instead of recreating a condition for scientific study purposes, Megan and her crew were simply trying to create a pleasant environment for recreation, in the sense of personal enjoyment.

The title text is a reference to 1949: Fruit Collider a pun of piña colada (Spanish for "strained Pineapple") and a particle collider: the Spanish word "colada" is pronounced similarly to the English word "collider". Taken literally, "piña collider" would be a pineapple collider, which may be interpreted as a fruit juicing machine for making piña coladas.

#2512: Revelation

September 06, 2021



AND I BEHELD WHEN HE HAD OPENED
THE SIXTH SEAL, AND, LO, THERE WAS
A GREAT EARTHQUAKE; AND THE SUN
BECAME BLACK AS SACKCLOTH OF HAIR,
AND THE MOON BECAME AS BLOOD.

~~~~~



HI JOHN, INCREDIBLE STORY, HOPE  
YOU AND YOUR FAMILY ARE SAFE.  
CAN CHANNEL 9 NEWS SHARE YOUR  
ACCOUNT IN BROADCAST AND PRINT?

~~~~~

And the heaven departed as a scroll when it is rolled together, but then more heaven kept appearing to replace it, as if the scroll was infinite.

Explanation

A user with a profile picture of a stick figure with hair, who could be on an island and is called John, posts the Bible text from Revelation 6:12 on a social media website. The author(s) of the book of Revelation refer to themselves as John; some religious scholars identify the author as John of Patmos or as John the Apostle. Thus it is likely that the user has the identity of the said John, either as this biblical-era person themselves (online communities existing in their time, or vice-versa) or adopting the historic character name for interpretive or parodic reasons. The comic places a Biblical event in the modern day to portray what it would be like for apocalyptic miracles to happen nowadays. It also depicts how even the epically largest of our most meaningful and moving moments can end up being treated online.

A news channel's official social-media monitor understands this to be an actual (natural) disaster in progress and asks for permission to use the posted information in a broadcast. This could be what would have happened if John had been using Twitter in his own time, in which case his Revelation might have received this response from that time's similarly-connected reporters, perhaps not comprehending the observations to be 'prophetic visions of the future', with potentially a different level of significance altogether, rather than reports of events just happened.

If the monitor has just found some form of dislocated

account (a very old message, a modern echo for proselytizing purposes or a jape of some kind) then they appear to have been drawn in, having not recognized it as historic text from the Bible.

Whichever way, the response is typical of a 'foot in the door' approach probably used for any and all candidate 'breaking news' citizen-reports, identified by trawling and searching the media-feeds for newsworthy content by either reporters or an 'algorithm'. As well as trying to ask for republishing permission, as per the duty of care reporters should grant to their sources, it is couched behind a typically bland statement of concern.

The reply may seem underwhelming,[citation needed] given the Revelation-level nature of the scenario, but this early in the reporting cycle the researcher may not have enough facts from which to respond more empathetically. Without any 'empathy' the channel and its staff may look entirely uncaring, but anything too effusive would also look unprofessional. Whether the news-organization and/or its staff could be truly concerned, or simply going through the motions, would highly depend upon their established reputation in the eyes of one viewing this exchange. Cynicism might be involved, all round.

The title text modifies verse 14 from "And the heaven departed as a scroll when it is rolled together; and every mountain and island were moved out of their places" to instead reference the infinite scrolling of a news ticker. Thus this news story would just be one on an infinite

scroll page of ever-new stories.

Alternatively, a Biblical-level disaster actually IS occurring, in which case the newscaster's response is underwhelming, to say the least.

Each of the described events happens at times. The Sun is black during an eclipse, the Moon is red when it sits at the horizon and/or in eclipse, and earthquakes happen on a frequent basis across the planet. When events happen together, it can have great significance, and people may become more disconnected from what is real or common nature as lives become digitized. Many people are so used to sunrises and sunsets while seeing the Moon high in the sky that they do not realise that the Moon also turns red when it rises and sets.

In 2014, a series of four total lunar eclipses were identified by some Christian preachers as being the "blood moon" mentioned in Revelation 6:12, but the world did not proceed to end.[citation needed]

#2513: Saturn Hexagon

September 08, 2021



Sorry, in SI units that's "there's a big football in there."

Explanation

Saturn's hexagon is a cloud formation on Saturn centered on its north pole. Similar to Jupiter's Great Red Spot, it is a persistent feature observed by multiple space probes. The cause was not known until recently, when data from the 2006-2009 Cassini–Huygens probe could be analyzed in depth. This finding was widely publicized in popular science media (see for example this) and is related to how currents flow deep within Saturn's atmosphere.

Cueball proposes an alternate explanation: it is the top of a soccer ball. Soccer balls are made in the shape of a truncated icosahedron, where faces alternate between regular hexagons and regular pentagons to achieve a more uniform roll. This design was introduced in 1968 as the Adidas Telstar, and is now considered the "traditional" soccer ball. The article refers to this as the "BSBIT model", a technical-sounding acronym from "Big Soccer Ball In There".

"Soccer" is the name used in the United States for association football, a game called simply "football" in much of the world. Similarly, the US makes wide use of customary units of measurement (inches, feet, miles, pounds, etc.) where much of the world uses the SI or metric system (centimetres, metres, kilometres, kilograms, etc.), so "football" is jokingly referred to in the title text as the SI name for "soccer". Just as the American customary units derive from earlier English units (that

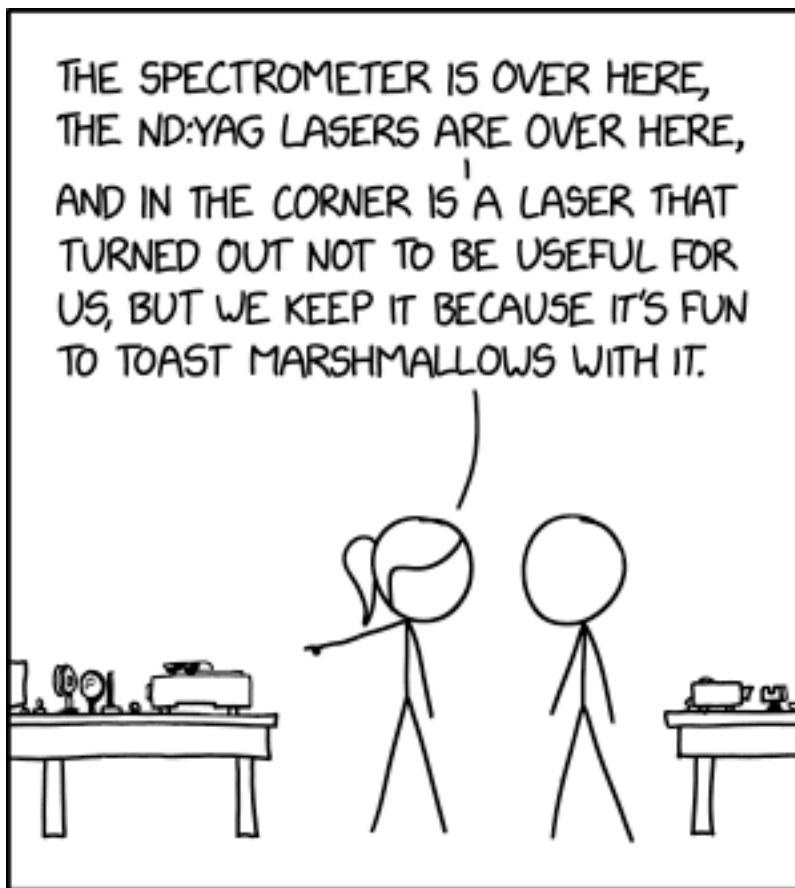
also developed into the British Imperial units), the term "soccer" originated in the UK, originally to distinguish it from rugby football (sometimes "rugger"), before soccer became the most common form of football there. A possible interpretation of this is that as much of the Web panders to a significantly US-based audience, many sites use only American customary measurements and omit metric equivalents, which might annoy non-US users; Randall parodies this by sarcastically and non-seriously apologizing.

This comic may also reference something often quoted to students decades ago that Saturn would float if there were a large enough pool of water to hold it, often having been stated as "Saturn is a giant beach ball". This refers to the property that Saturn is the planet with the lowest average density. This, of course, is a lot more complicated in reality.

Incidentally, the presentation of the truncated-icosahedral 'football', pressing one clear polygonal face up along the upper limit of the planetary sphere, has much in common with the (non-truncated) icosahedron that floats within a Magic 8-Ball, arranged to display just one random triangular face whenever its viewing window is upwards. This may be coincidence. Randall has previously parodied the magic 8-ball in 1525: Emojic 8 Ball.

#2514: Lab Equipment

September 10, 2021



EVERY LAB IN EVERY FIELD HAS
SOME PIECE OF EQUIPMENT LIKE THIS.

I've been working on chocolate bar annealing techniques to try to produce the perfect laser s'more. Maybe don't mention that on the grant application though.

Explanation

While giving Cueball a tour of the lab equipment, Ponytail shows a spectrometer — a device that examines light emitted from or passed through samples to fingerprint emission or absorption lines in the mix of light. Next she shows the "Nd:YAG" lasers. It is unknown if the multiple lasers are for redundancy or if they have different specifications and are for different tests. "Nd:YAG" stands for neodymium-doped yttrium aluminum garnet; it is a lasing medium commonly used in lasers. Lastly she shows off a decommissioned laser not used in experiments, but rather for toasting marshmallows.

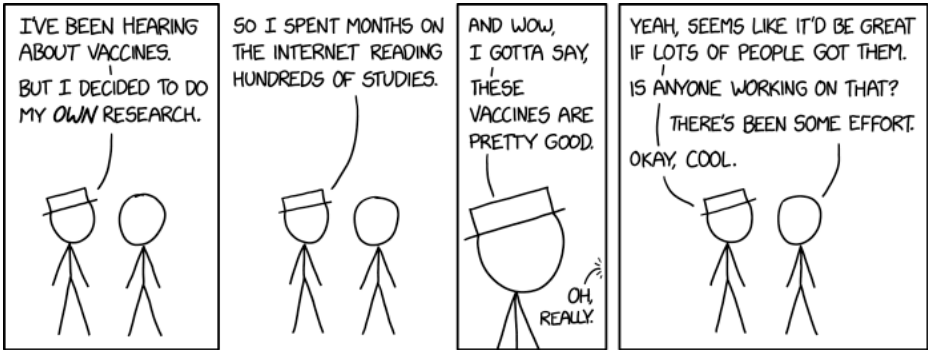
The claim that such things are almost universal is, in fact, very realistic. When doing any research, especially cutting-edge research, it's often difficult to predict what equipment will be useful or not, so it's inevitable that some things will be purchased, and not turn out to be very effective in their experiments. Some of these things will end up being sold, put into storage, repurposed, or even thrown away, but some equipment is enjoyed by the researchers, despite a lack of official uses, and so will end up being kept around. Researchers, being human,[citation needed] are going to do some things in the lab for their own amusement, rather than because it's part of a formal experiment, and if equipment has already been purchased, keeping it because it's enjoyable is usually overlooked. Additionally, just playing around with high-end equipment can occasionally lead to useful

discoveries. Basic research is difficult to plan out, and sometimes just letting scientists play around with powerful equipment can produce unexpected results, which can lead to new scientific understanding.

The title-text mentions that she's using "annealing techniques" to make the perfect s'more. A s'more is a popular treat in the United States and Canada, consisting of one or more toasted marshmallows and a layer of chocolate sandwiched between two pieces of graham cracker. Annealing is more commonly a heat-treatment technique used to influence the nature of the crystals in metals for structural reasons. This is done when jewelry is molded from molten metal, but more likely Randall means a use of annealing in scientific research. Annealing is also used in glass production. This suggests that Ponytail is trying to use lasers and/or other specialized heating equipment to control the melting process of the chocolate, in conjunction with precision toasted marshmallows, to perfect this treat. She points out that this shouldn't be mentioned on the grant application. When labs apply for grants to purchase or upgrade equipment, or to fund research projects, they emphasize the scientific principles that could be advanced (and potential useful products that might be produced) as a result of their research. The idea that researchers might be using the equipment to amuse themselves and work on whimsical side projects would be unlikely to impress the groups offering the grant,[citation needed] even though, as Randall points out, such things are pretty much ubiquitous.

#2515: Vaccine Research

September 13, 2021



Honestly feel a little sheepish about the amount of time and effort I spent confirming "yes, the vaccine helps protect people from getting sick and dying" but I guess everyone needs a hobby.

Explanation

This comic is another entry in a series of comics related to the COVID-19 pandemic, specifically regarding the COVID-19 vaccine.

The comic starts with White Hat using a common conversational tactic used by vaccine skeptics, and conspiracy theorists, in order to try to persuade others, typically claiming that they did their own research. The phrase "done my own research" is often taken to mean that the speaker is skeptical of the topic, and has done only cursory fact-checking, typically consulting only nonscientific sources that confirm and validate their prior beliefs. However, subverting expectations, it seems that White Hat genuinely had researched the subject deeply, consulting a large number of primary sources, and coming to a conclusion matching the overwhelming scientific consensus that vaccination against COVID-19 is safe and effective. The conclusion he expresses is humorously simple, but entirely in keeping with every expert analysis: "These vaccines are pretty good... Seems like it would be great if lots of people got them."

In the last panel, White Hat asks if there are any efforts to distribute the vaccine, to which Cueball responds with understated irony. Anyone genuinely informed about the vaccines would have to be aware of the huge scale of vaccine rollout efforts, or of the resistance to them. It strains credulity that someone could read "hundreds of studies" on the topic and not be aware of how many

people had been vaccinated. Cueball, however, doesn't mock White Hat's incongruous ignorance, but simply responds that there's been "some effort", which satisfies White Hat.

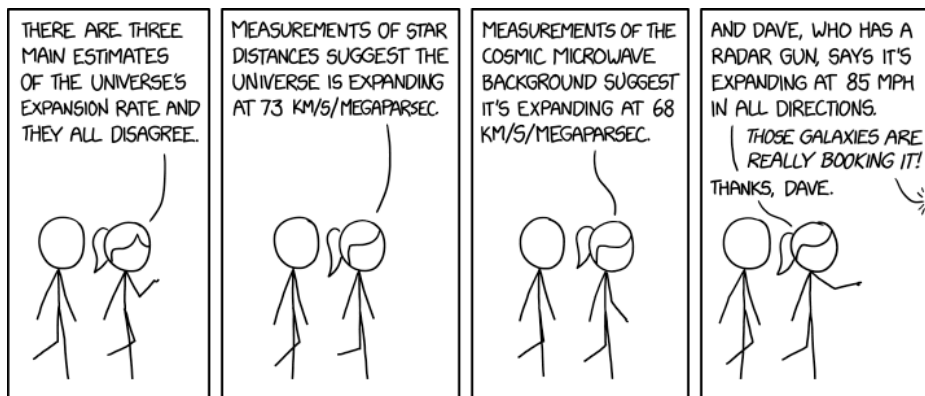
At the time this strip was posted, only about 42.3% of the world population had been vaccinated against COVID-19. In low income countries, however, distribution has been negligible, and the rate is below 1.9%.

In the title text, Randall comments that he feels a little sheepish that he has spent way too much time and effort confirming the statement "yes, the vaccine helps protect people from getting sick and dying". This has been known for a long time despite the anti-vaxxers' efforts. But, as he states, this could be seen as a hobby. Anti-vaxxers also often refer to people who get vaccinated as "sheep" or "sheeple"; although, this may have dire consequences.

This comic may be a sort of spiritual successor to 2281: Coronavirus Research.

#2516: Hubble Tension

September 15, 2021



Oh, wait, I might've had it set to kph instead of mph. But that would make the discrepancy even wider!

Explanation

Ponytail is telling Cueball about the expansion of the universe telling him that there are three main estimates of the rate of expansion, and that they all disagree. She then tells him of the two well known (and very complicated) methods, and finally the joke is that the third method is performed by a guy named Dave (who replies from off-panel), and he claims to measure the speeds with a radar gun, as if the galaxies were speeding here on Earth.

The fact that most galaxies are receding from us, and that the distance to the galaxy is directly proportional to the speed (as measured by red-shift) was discovered in the 1920s by Edwin Hubble and others. This constant of proportionality is known as the Hubble Constant.

One way of measuring the Hubble Constant is to measure the distance to (relatively) nearby galaxies. Once distance is obtained, speed can be easily obtained by measuring the red-shift and thus the Hubble Constant calculated. Measuring the distance turns out to be fiendishly difficult because a distant bright star looks the same as a dim star that is closer, and localized movements can influence the speed of recession — though less significantly, for multiple reasons, the further away are the objects that you study.

In practice, astronomers have a number of ways of measuring distance that work at different scales, and they can be built upon to measure distance to far away

galaxies. This is known as the Cosmic distance ladder.

The first rung is parallax. As the Earth orbits around the Sun, nearby stars appear to move slightly relative to distant stars; a star that moves by one second of arc is said to have a distance of 1 Parsec — about $3\frac{1}{4}$ light years or 30 trillion (3×10^{13}) kilometers.

The next rung is Cepheid variables, which periodically brighten and dim. The frequency of variation is related to the absolute brightness of the star, and thus by comparing the absolute to the relative brightness (subject to the Inverse-square law where not otherwise obscured) the distance can be measured.

The final rung is Type Ia supernova, which occur when an accreting white dwarf exceeds 1.4 solar masses. Because the initial mass is always identical, the absolute brightness of the explosion is as well, so the distance can be similarly calculated.

Putting these together, the best measurement of the Hubble Constant is 73 km/s/Mparsec.

This is in conflict with the other main way of measuring the Hubble Constant, analyzing makeup of the Cosmic Microwave Background (CMB) radiation, which yields a value of 68 km/s/Mparsec. The difference is statistically significant, and well outside the error bounds of each measurement.

Since the CMB technique relies on our understanding and assumptions about the early universe, as well as on

the cosmological effects of General Relativity on large scales, if this discrepancy proved real it could be the gateway to new discoveries in cosmology and gravity, as well as possibly shed light on the origin of the universe and a 'Theory Of Everything'. Cosmologists got quite excited about this. It might also be that there was a previously unaccounted-for error in any of the rungs of the cosmological distance ladder and, once that is fixed, the two results will be consistent.

The third method introduced in this comic is a guy named Dave who is trying to use a radar speed gun (as used by the police for detecting speeding cars) to try to measure the movement of astronomical bodies. A radar system works by sending electromagnetic radiation from the gun and then measuring the returned radiation to determine how far away or how fast a moderately distant object is moving. Because of the transmission and return times required (and the inverse-square law), a radar device will only be able to get information about the very closest objects, such as the Moon (a type of Moon bounce) and other objects orbiting the Earth (or perhaps the Sun), where the influence of being in orbit utterly dominates over any possible Hubble-shift. Doing that still needs very powerful radar systems like the former Arecibo Telescope to be able to get any useful information from that far away; a hand-held radar gun would not be able to 'lock on' across those distances, let alone distant galaxies.

Going by back-calculating grossly 'idealized' universe models, as suggested by the other two estimates, a

receding velocity of 85 miles per hour ('mph'; about 137 kilometers per hour, 'kph' or 'km/h') should be seen at a distance of roughly 1700-1850 light-years, on the order of the thickness of our galactic disc. Much too far to use a radar gun on, also much too close to exclude any significant galactic stellar motions. Much the same is true if the figure is actually 85 kph (1050-1130 ly), as suggested it might be in the title text.

Aside from being practically incorrect, that value of 85 kph relates to around 53 mph, which might be the normally observed traffic speed on certain roads (especially if someone is conspicuously using a radar gun!) if by 'all directions' you effectively mean 'both directions' of traffic flow that Dave could possibly be measuring. Dave may have been referring to the kind of Galaxy that he can more easily find out the velocity of.

The comic is likely making fun of the common internet phenomenon of amateur (wannabe?) scientists seeking to discredit established scientific facts by reporting the results of experiments made using everyday tools. Dave has probably heard of the fact that there is no agreement in the scientific measurements of the Hubble constant and decided to try to settle the controversy using the tools at his disposal, without remotely realizing that the margin of error required in the measurements is well outside the range of what can be used with conventional objects.

Dave might also lack an understanding of units of measure and dimensions. Ponytail describes the

measurements of the rate of universal expansion, a speed that varies with distance, in km/s/Mparsec , having dimension $1/T$ or $1/\text{time}$. Dave made his measurements in miles/hour or km/h , which have dimension L/T or length/time. These are not comparable with the official units. Dave does not appear to be aware of this (and Ponytail does not draw Cueball or Dave's attention to it).

#2517: Rover Replies

September 17, 2021



THE MOST UNEXPECTEDLY WHOLESOME
PLACE ON THE INTERNET IS THE REPLIES
TO NASA'S ROVERS ON SOCIAL MEDIA.

I'm so glad NASA let you take your phone to Mars!

Explanation

There is a Twitter account for NASA's Perseverance Mars Rover, which collected samples. The Twitter account tweets in the first person like in the comic. Likely a human on earth is playing the role of the rover.[citation needed] While the exact post shown does not exist, it has posted a similar tweet.

The first four replies (in order of top-to-bottom) are likely just general compliments to the rover, demonstrating that the replies are indeed wholesome. Reply three in particular references rocks, as the main purpose of most Mars rovers is to perform Martian geology.

Reply five is a mashup of conspiracy theories, including about 5G communications, vaccines, and others. Ponytail then replies "Quiet, we're not doing that here", scolding the conspiracy theorist to keep their negativity out of the otherwise positive forum.

The next reply references people saying where they're from, then clarifying where that is in brackets, e.g. Wingerworth (England). This commenter expands that to clarify that they are from Earth, joking that the planet may be ambiguous as the Mars rover is not on Earth. In reality, this ambiguity does not exist as humans only live on Earth,[citation needed] thus contributing to the humor.

The second-to-last reply is likely a misunderstanding, with the commenter believing that the rover is digging to perform anthropology or paleontology, not geology. The commenter could, however, believe that there is/was complex life on Mars, thus allowing the possibility that there are Martian skeletons for the rover to find.

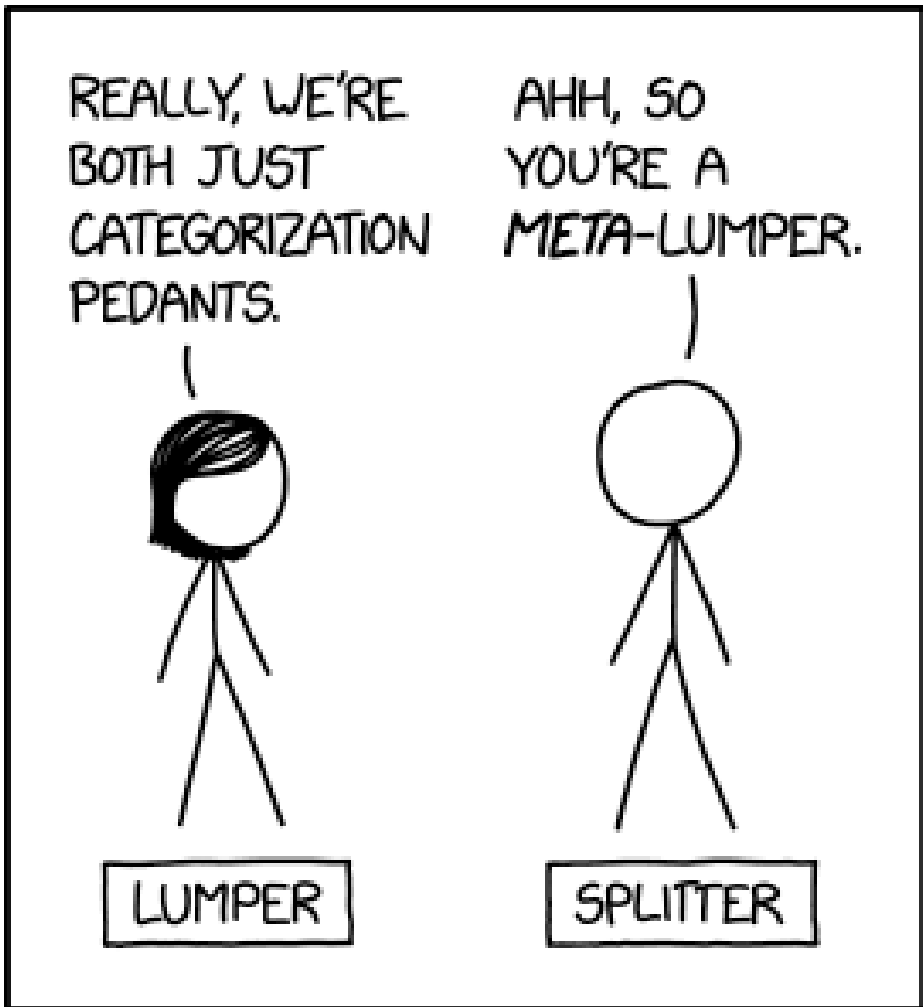
The final reply is a reference to Ingenuity, a small helicopter which Perseverance took to Mars as a technology demonstrator. It has been very successful and completed many flights, often taking it quite far from Perseverance.

The title text is in the form of another reply. The character posting that reply believes that the rover has taken its phone to Mars, and has used that to take the pictures. This is likely because most photos on social media are taken on phones, and social media sites are often designed for phones. In addition, Perseverance and Curiosity differ from previous rovers in that they have cameras mounted on flexible arms, allowing them to take photographs of themselves - somewhat akin to a smartphone on a selfie-stick. In reality, Mars rovers don't have smartphones, and Perseverance is taking photos with an equipped camera.

While this comic is most likely referencing Perseverance, there is another small possibility that Curiosity is shown here, as Curiosity also has collected samples. This is unlikely though due to the timing of this comic.

#2518: Lumpers and Splitters

September 20, 2021



Anna Karenina is a happy family lumper and unhappy family splitter.

Explanation

It is common to separate groups of things — species, people, languages, software models, etc. — into categories, but different people may do this in different ways. "Lumpers" work from the ground up by focusing on similarities among individual things to create larger categories, while "splitters" do the opposite, taking larger categories and trying to find characteristics that are not shared by all members of the group to further divide them into smaller subsets.

The comic points out the meta-ness of categorizing people based on how they categorize. It labels Megan and Cueball as those two types of categorizers. Megan, the lumper, describes herself and Cueball as both being "categorization pedants", lumping the two distinct categories "lumpers" and "splitters" into one. Cueball, the splitter, subcategorizes Megan into a more specific type of lumper: a "meta-lumper"—since the things Megan was lumping includes lumpers themselves—thereby splitting off lumpers from meta-lumpers. If Cueball further categorized himself he would be a meta-splitter.

The title text references the opening line of the novel *Anna Karenina* by Leo Tolstoy, which reads (as translated into English), "Happy families are all alike; every unhappy family is unhappy in its own way." Randall is drawing a parallel between this line and the lumpers/splitters distinction because the line lumps one group of things (happy families) while splitting another

group (unhappy families).

Additionally, this may be a reference to the podcast episode "Lingthusiasm Episode 60: That's the kind of episode it's - clitics" , published a few days before the comic, wherein the hosts separate people into lumpers and splitters of clitics.

#2519: Sloped Border

September 22, 2021



IF I'M EVER PUT IN CHARGE OF A COUNTRY, I'M GOING TO SPEND ALL MY TIME TRYING TO THINK OF NEW WAYS TO MAKE LIFE A NIGHTMARE FOR GIS PEOPLE.

"The slope will be 74° at ground level." "Okay, I think we can hack together a ... wait, why did they specify ground level? It's 74° everywhere, right? ... Oh no, there's a whole section in the treaty labeled 'curvature.'"

Explanation

Every country has land and sea international borders that demarcate the extent of their territory and their legal jurisdiction. These borders are established through law, treaty, or consensus. Establishing an international border is maintained by present-day customs, immigration, and security checks. Some countries (like Cyprus) have established a buffer zone outside of their international border in order to gain additional protection during a conflict, and most countries have an offshore Exclusive Economic Zone in order to preserve exclusive proprietorship of marine resources such as oilfields and fishing grounds.

In this comic, Cueball and Blondie have established a "sloped" international border through a treaty. Usually borders are perpendicular to the ground[citation needed] so that all the air(space) above the ground belongs to the same country. This is called Air sovereignty. Thus it suffices to define the border on the earth surface, as 1D lines across the curved 2D surface. The precise definition is that a line from the center of the Earth through the point of the border is drawn. Sloped terrain is immaterial to the border of the air sovereignty which is still vertical, even if not perpendicular to the terrain.

If the borders were sloped (with respect to the horizontal ground level) an airplane would need to know its precise height to decide if another country's jurisdiction currently applies. With the help of the Global

Positioning System this would be in principle possible, although the height information of GPS is less reliable. (It might be possible to program a computer to use altitude data from the airplane's altimeter along with latitude and longitude data from the GPS and a relevant ground relief database to make an accurate determination.)

Most countries would not agree to a border that cuts into their airspace and shrinks their territory as the altitude increases; most cases of countries losing area have come about as a result of trying to avert, or losing, an armed conflict. It is entirely possible that Cueball's country has compelled Blondie's country to accept its demands, of which the redrawn border is one. Alternatively, Cueball's country may be deliberately reducing its own airspace purely because it will cause problems. It is also equally possible that Blondie's country has accepted the airspace loss in exchange for the potential mineral and mining rights from the portion of Cueball's country, potentially due to a more prevalent mining economy in hers vs a more prevalent aerial defense force or space program for Cueball. A sloped border like this could resolve an issue of Cueball's country's rockets passing through a neighboring country's air space, which would be unwelcome, and so the sloped border allows the rockets to be steered into the additional airspace, thereby preventing conflict.

There is at least one famous case of a border being affected by elevation: the Franco-Swiss border bisects the staircase of the Hotel Arbez. Thus, although part of the

upper floor is geographically in France, the entire floor is Swiss territory, because it is only accessible through Switzerland.

The mathematical computation for an angled air sovereignty seems relatively straight-forward at low level and could be expressed with a single line of code or a single equation, although the people acting on the information are likely unfamiliar with code and equations and likely use tools with completely no support for sloped borders. The mention of curvatures in the title text may reveal some emergent problems that need accounting for.

A totally straight line drawn far enough upwards at an angle will find the surface of the Earth curving away beneath it (not even considering terrain undulations) and the angle to the local vertical will reduce as it continues, tending towards vertical as you head towards infinite altitude.

Alternately (although it seems this is not the case) the profile of the sloped border may be assumed to remain at a constant angle to the shifting vertical, in which case it describes a certain form of spiral (which will eventually loop around the earth).

A third option is that it gains altitude at a constant rate, with respect to the passage of land measured on its surface track, to form a different spiral, in which case it will still loop around the Earth but at an angle that increasingly tends towards horizontal.

While the comic doesn't mention this, such a boundary should probably also extend underground, in the opposite direction. (The straight-line version, if implemented, will eventually reach a depth at which it is tangential to the radius and then rise back through the surface an equal distance further around the planet.) This would then impact, at practical depths for such things, planning rights for property foundations and, at deeper levels, mining rights for minerals.

Practically, an upper-limit to a nation's claim (somewhat below satellites, e.g. the Karman Line) and a lower limit (well before reaching the Earth's mantle) will prevent many of these complications, together with intersections with other (probably vertical) 'territorial volume' borders that will supercede in any compound claims to ownership. - However, it is still very important to specify exactly which curve (i.e. with respect to what) the boundary is designed to be respecting.

"GIS" refers to geographic information system, a set of tools and methods for capturing, analyzing and presenting spatial and geographic data. While altitude is already an (optional) element in the blocks of information, people developing these systems would be inconvenienced by the additional requirements demanded by the border described in the comic.

It is possible this comic is inspired by such boundary disputes as the Beaufort Sea 'wedge' which, while in this case perpendicular to the surface, suffers from alternative interpretations of how to extend it from the shoreline

out towards international waters.

#2520: Symbols

September 24, 2021

SYMBOLS

AND WHAT THEY MEAN

$\frac{d}{dx}$	AN UNDERGRAD IS WORKING VERY HARD
$\frac{\partial}{\partial x}$	A GRAD STUDENT IS WORKING VERY HARD
\hbar	OH WOW, THIS IS APPARENTLY A QUANTUM THING
R_e	SOMEONE NEEDS TO DO A LOT OF TEDIOUS NUMERICAL WORK; HOPEFULLY IT'S NOT YOU
$(T_a - T_b)$	YOU ARE AT RISK FOR SKIN BURNS
N_A	YOU'RE PROBABLY ABOUT TO MAKE AN INCREDIBLY DANGEROUS ARITHMETIC ERROR
μm	CAREFUL, THAT EQUIPMENT IS EXPENSIVE
mK	CAREFUL, THAT EQUIPMENT IS <i>VERY</i> EXPENSIVE
nm	DON'T SHINE THAT IN YOUR EYE
eV	<i>DEFINITELY</i> DON'T SHINE THAT IN YOUR EYE
mSv	YOU'RE ABOUT TO GET IN AN INTERNET ARGUMENT
mg/kg	GO WASH YOUR HANDS
Mg/kg	GO GET IN THE CHEMICAL SHOWER
π or τ	WHATEVER ANSWER YOU GET IS GOING TO BE WRONG BY A FACTOR OF EXACTLY TWO

"rntgen" and "rem" are 20th-century physics terms that mean "no trespassing."

Explanation

This comic refers to elements of (mostly mathematical or engineering) notation commonly used in various fields of math and science. Each piece of notation is presented as "symbolizing" not what it specifically means, but a typical context in which it might be encountered, see below.

Many of the individual descriptions look like verbiage that might be found on informational or warnings signs or placards, although typically with a silly edge.

The title text refers to two non-SI units of radiation measurement, röntgen and rem. In the mid-20th century when they were in use, the dangers of radiation weren't as well understood as today, so an area with radiation that was noteworthy back then is probably dangerous, hence the no trespassing part.

Later Randall made a similar comic, 2586: Greek Letters, regarding the use of Greek letters in math.

Symbols[edit]

$\frac{d}{dx}$: An undergrad is working very hard $\frac{d}{dx}$ is the symbol for a single-variable derivative. This is one of the basic operations in calculus and consequently is ubiquitous in the work of undergraduates in the sciences. A hard-working undergraduate in the relevant fields would churn through exercises using this symbol.

∂∂x: A grad student is working very hard The replacement of the standard "d" letters with the curly letters "∂" denotes the partial derivative, which generalizes the ordinary derivative to multi-variable calculus. Problems with partial derivatives, especially partial differential equations, can be extremely challenging. Although PDEs would typically be first taught at an undergraduate level, difficult partial derivatives would be encountered in graduate-level work.

ħ: Oh wow, this is apparently a quantum thing ħ (pronounced "h-bar") is a symbol used for (the reduced) Planck's constant, a universal, fundamental constant in quantum physics. h, the normal version of Planck's constant, is equal to the energy of a photon divided by its frequency. ħ is equal to $h/2\pi$, and angular momentum in quantum mechanical systems is measured in quantized integer or half-integer units of ħ.

Classical physics appears as a limit of quantum physics if all "actions" (quantities of dimension energy * time, momentum * length, or angular momentum) are much larger than ħ. Conversely, you can also formally set $\hbar=0$ to get classical results from quantum formulae. This means that effects that are proportional to some power of ħ cannot be explained classically, and instead are "a quantum thing".

Re: Someone needs to do a lot of tedious numerical work; hopefully it's not you The Reynolds number (which is usually denoted by "Re," not "Re" as it appears in the comic) is the most important dimensionless group in fluid mechanics. Named for Osborne Reynolds, Re characterizes the relative sizes of inertial and viscous effects in a moving fluid. Large values of Re are indicative of turbulent flow, which cannot usually be retrieved

analytically, and so numerical modeling is necessary. Accurate numerical studies of high-Reynolds-number flows are notoriously difficult to create and program.

Alternatively, Re could stand for electronic transition dipole moment in a molecule. This appears in quantum-mechanical calculations of transition probabilities and also includes a lot of unpleasant numerical work. Re is also a term used for the radius of the Earth at mean sea level, though this is not necessarily a complex term in and of itself.

Another alternative is that Re could refer to Relative Error, a measurement of precision or accuracy. Used often in the analysis of scientific data and numerical analysis.

($T_a - T_b$): You are at risk of skin burns The Stefan-Boltzmann law says that a perfectly absorbing ("black body") source emits electromagnetic radiation with a power per unit area of σT^4 , where σ is a known constant and T is the absolute temperature. The quantity ($T_a - T_b$) thus appears in any calculation of purely radiative energy transfer between two bodies, one at temperature T_a and the other at T_b . When the radiative transfer is large enough to be the most important form of heat interchange, it is normally also large enough to sear the skin with thermal or ultraviolet burns.

NA: You are probably about to make an incredibly dangerous arithmetic error NA, or Avogadro's number, is the number of molecules in a mole of a substance, approximately the number of carbon atoms in exactly 12 grams of carbon-12. This is an enormous number, exactly $6.022\,140\,76 \times 10^{23}$, or 602 214 076 000 000 000 000 000. Working with NA, it is easy to accidentally

divide by it instead of multiplying or vice versa, leading to erroneous and nonsensical answers such as $\sim 10^{-23}$ molecules (even though you can't have less than 1 whole molecule) or $\sim 10^{46}$ moles ($>10^{43}$ to 10^{45} kilograms, depending on the chemical - tens to hundreds of times the estimated mass of the Milky Way Galaxy) of a substance.

μm : Careful, that equipment is expensive Micrometers are a very small unit of distance. Micrometers are commonly used to measure wavelengths in the infrared, and infrared detectors are very expensive, compared with visible wavelength counterparts. Of course, micrometers are used as a measurement of distance in other contexts, but any distance-measuring device capable of accurately measuring micrometer distances would also be expensive. Similarly, tools used to create or calibrate items within micrometer tolerances can also be expensive.

mK: Careful, that equipment is very expensive Kelvin is a temperature scale roughly speaking similar to Celsius, but taking absolute zero as its zero point instead of the freezing point of water (rigorously speaking, its definition is now based on the Boltzmann constant). Millikelvins ($1/1000$ of a Kelvin) are used for high precision temperature work. Frequently this is used in processes of cooling temperatures to nearly absolute zero - such as superconductors or other quantum effects that occur when atoms are almost still. This is suggesting that the symbol appears on a sensitive experimental system probing quantum mechanical behavior that would likely only exist in an advanced laboratory. Any equipment that works down at mK temperatures, or at least to mK precision and accuracy, is likely to be very expensive.

nm: Don't shine that in your eye Nanometers are frequently seen

in the listed wavelengths for lasers. Pointing a visible or infrared laser at someone's eye is notoriously dangerous; the tightly-focused coherent light can cause permanent damage very quickly.

eV: Definitely don't shine that in your eye Electronvolt energies are typical of moderate-energy particle beams, produced by accelerating electrons (or protons) over macroscopic voltages. These particle beams can be even more damaging (and are probably a direct reference to Anatoli Bugorski) to soft tissues than optical-wavelength lasers.

mSv: You're about to get into an Internet argument The millisievert is a unit of radiation dose absorbed. It is a very small dosage, but the joke refers to Internet trolls debating the effects of low-dose radiation sources, such as 5G wireless networks. Randall's comment may also be referring to Radiation.

mg/kg: Go wash your hands This unit measures the dose of a drug or other chemical in milligrams per kilogram of body mass. If the appropriate dose - or worse, the lethal dose - is measured in mg/kg (parts per million), then the substance may be quite toxic.

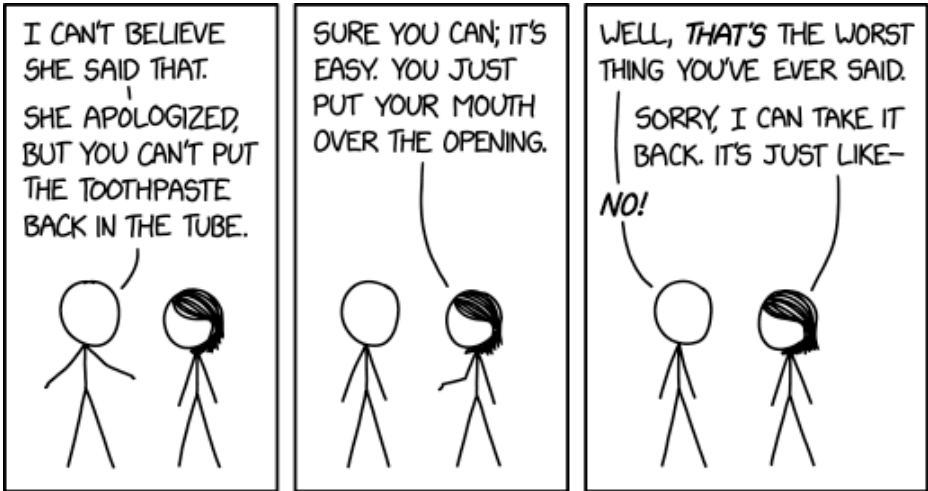
μg/kg: Go get in the chemical shower A unit 1/1000 times the size of mg/kg. If a dosage is measured in micrograms per kilogram (parts per billion), any accident probably requires whole-body decontamination procedures.

π or τ : Whatever answer you get will be wrong by a factor of exactly two π is defined as the ratio of a circle's circumference to its diameter, while τ is defined as the ratio of a circle's circumference to its radius (and is therefore equal to 2π). π has

been used as the primary constant for describing the circumference and area of circles millennia ago, but proponents of τ claim that τ is more natural in most contexts since it makes working in radians more straightforward. Actually, the "Pi" symbol used to be occasionally used for the constant now called Tau. The joke here is that whichever constant you use, it will probably be the wrong one (off by a factor of two, one way or the other) for the formula you are trying to use. The debate over Pi vs. Tau was solved by Randall in this compromise: 1292: Pi vs. Tau.

#2521: Toothpaste

September 27, 2021



"9 out of 10 dentists have banned me from their offices."

Explanation

Cueball is telling Megan about his friend. He indicates that she said something shocking and probably hurtful. He then states that even though she tried to apologize it was too late, the words had been said and it cannot be taken back.

He uses a phrase to underline this: You can't put the toothpaste back in the tube.

Putting toothpaste back in its tube is often used as an analogy for something irreversible, such as how you can't undo speaking. Megan, however, rejects this assertion and says that you actually can put toothpaste back in its tube, which is certainly possible in some cases. There are many ways to do this, and none of them are recommendable if the toothpaste has come into contact with something non-sterile. But she chooses a particular nasty one where she would blow the paste in her mouth back into the tube. This is obviously much more unsanitary than simply returning unused toothpaste to the tube, which someone might reasonably want to do after squeezing out more than they wanted.

Cueball is so disgusted by this suggestion that he states that Megan's suggestion is the worst thing she has ever said.

The joke then comes when Megan assumes that Cueball's original analogy still holds, that taking words

back is like putting toothpaste back in to the tube. So therefore she can actually unsay something. She starts to say exactly what Cueball's other friend did "Sorry, I can take it back". But then she says, "It's just like--", and was presumably about to continue, "--putting toothpaste back in the tube" (or perhaps, since it's Megan, was going to give a new analogy that was even worse). However, Cueball forcefully interrupts her, because the idea of putting toothpaste back in the tube now evokes the distasteful mental image of Megan blowing used toothpaste back into the tube.

Toothpaste is normally loaded into the tube from the back, before it is crimped shut. However, it should technically be possible to push an extruded amount of paste back in from the front by wrapping one's lips around the whole front of the tube and blowing the paste you have in your mouth back in. This positive pressure can re-inflate the tube the same way one blows up a balloon. However, blowing the toothpaste back into the tube would be highly unsanitary, and as the main purpose of toothpaste is to clean teeth, the end result is both counterproductive and disgusting.[citation needed] In some cases paste coming out of a tube will be sucked back in if the pressure is released. Such containers would probably be able to suck toothpaste back in, if it was still lying on the toothbrush in one blob (or on the table/in the sink if dropped). As above mentioned this would be unsanitary as germs etc. could get back inside the tube, where the paste is supposed to be clean.

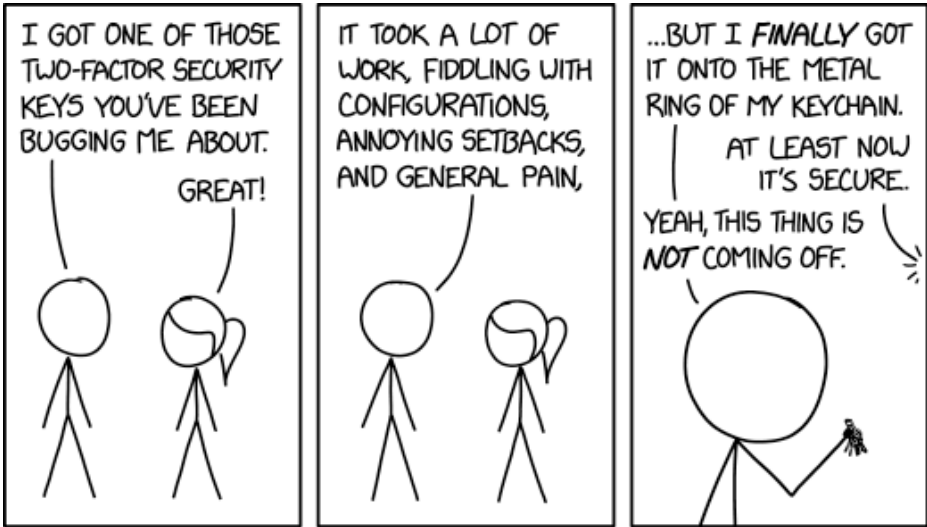
The title text spoofs a common line found in toothpaste

commercials: "9 out of 10 dentists recommend using our brand." This statement is very easily manipulated through any number of basic marketing tactics (such as only asking 9 dentists, whom are all paid handsomely), and its ubiquity lends it to spoofing. In this case, it's spoofed by saying that nine out of ten dentists are dissatisfied with Megan's approach (or with Randall and his ideas, as it is usually he who speaks in the title text; if it refers to Randall himself it is reminiscent of all the conferences he has been banned from) and have banned the toothpaste spitter from their offices.

It may actually say more about any dental establishment that does not disapprove of what Megan apparently is not just theorizing about doing - but maybe they are disapproving too, just not considering it bad enough to ban her from office.

#2522: Two-Factor Security Key

September 29, 2021



The bruises on my fingertips are my proof of work.

Explanation

Two factor security authentication (also see #Trivia) is something that Ponytail has clearly been talking to Cueball about. In this strip, Cueball is telling her that he has finally buckled down and gotten the two factor security key that she has pestered him to get.

He recites the trials that he endured in "installing" the key, all of which seem plausible configuration issues for setting up a proper two-factor authentication from scratch. However it is then revealed that all this work was just the task of attaching the 'key' (which looks like it could be a common brand of physical two-factor key fob or dongle) onto his metal keyring.

Metal keyrings are reliably secure as far as keeping a key attached, but this is in part because of how notoriously difficult it is to add a key to or remove a key from them. The rings must be forced apart and held apart while the key traverses however many layers the ring has (usually two or three, though keyrings with more layers are not unheard of). Cueball confidently asserts (to off-screen Ponytail, who probably was expecting something more practical) that his key is not coming off, indicating both a (well-founded) faith in the keyring's ability to keep his key, and a desire to not go through the same process in reverse. Presumably all his effort was in "installing" the key onto the keychain, and he probably hasn't actually set it up for any of his accounts, leaving them just as insecure as they were.

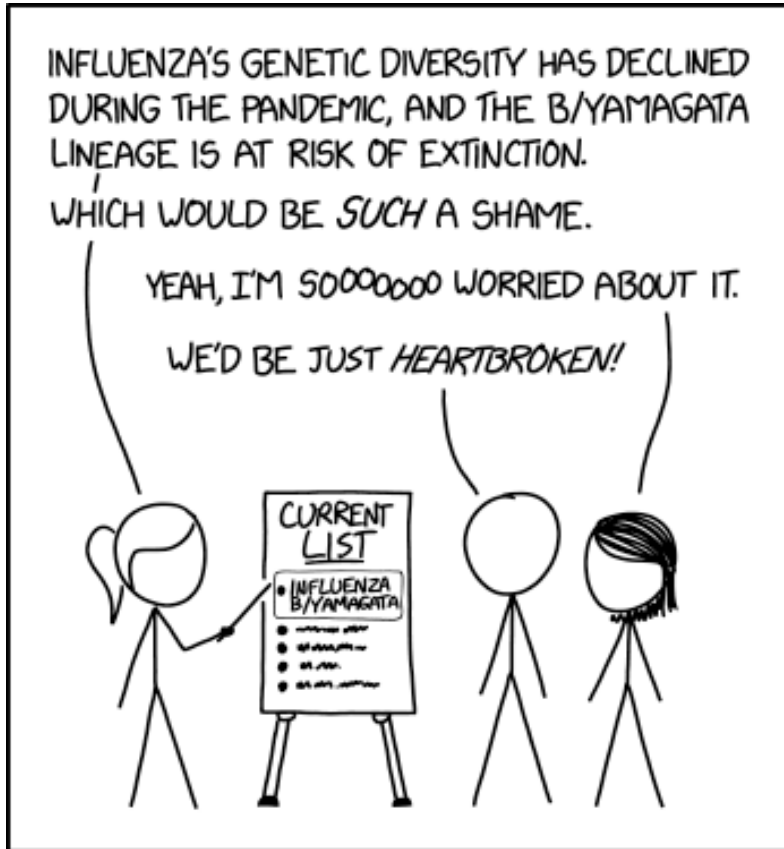
The title text has a similar double meaning. Cueball would of course use it to the "proof" of his efforts installing the key--though difficult, metal keyrings can be forced apart physically by human hands, at least if the human in question has fingernails sturdy enough to slip between the rings, at which point the insertion of a finger would be enough to keep it apart until the key is inserted. However, keeping the rings apart can be strenuous on the fingers, and can result in bruising, which Cueball is all too familiar with. Proof of work alludes to the cryptographic concept, which ties (sideways, as proof of work is a security term for a concept intended to deter denial of service and similar volume-based attacks but not directly related) back into the two-factor authentication.

Additionally a third meaning could be that while he spent a lot of time setting up 2FA he totally overlooked the possibility of him losing his whole keychain thus locking him out of all the services that requires 2FA if he didn't set up yet another layer of backup.

Another possibility is that the key is a physical authentication key, for example a YubiKey. These are very commonly used as a second authentication method.

#2523: Endangered

October 01, 2021



WHEN A PATHOGEN THAT SCIENTISTS REALLY DON'T LIKE IS CLOSE TO DISAPPEARING, IT GETS ADDED TO THE SARCASTIC ENDANGERED SPECIES LIST.

The list includes polio, Guinea worm, and this one particular enterovirus strain that they've been tracking out of spite after it went around the lab a few years ago.

Explanation

The endangered species list (also known as the IUCN Red List) is a system for categorizing species based on "level of extinction". This list is primarily focused on macroscopic organisms such as animals and plants, as it is these organisms whose extinction is easiest to quantify, and on which most conservation efforts focus. Generally, it is a serious concern when a species is listed on the endangered species list, as this indicates its extinction could be at hand. Ponytail, Cueball, and Megan in this comic are scientists who maintain an endangered species list of microscopic pathogens. People generally want pathogens and parasites to go extinct,[citation needed] unlike harmless plants and animals, so each species added to the pathogen endangered species list is a cause for celebration rather than concern, and the characters in the comic indulge in this celebration by sarcastically pretending to be upset about the potential for pathogen extinction, while in reality being excited about the possibility.

The title text mentions some of the species on the list, including polio and Guinea worm disease - diseases that have historically sickened and killed many people but are currently being eradicated due to worldwide efforts - the former, famously, through vaccination, and the latter through education and prevention techniques. As their eradication proceeds, they become more and more endangered of extinction, and thus earn their place on the list. The title also mentions a much less important

pathogen, namely a certain strain of an enterovirus, also known as a stomach flu, which unlike polio and guinea worm is likely only to cause temporary discomfort, not death or long-term disability, in infected people. However, the strain in question infected every member of the lab maintaining the list, and as a result of their personal negative experience with it, and the spiteful feelings that resulted from that experience, the characters will celebrate its extinction as much as that of polio, and have accordingly added it to the list. (A similar revenge-based public health policy to combat SARS-CoV-2 was discussed in 2448.)

Randall was most likely inspired by this article about different influenza strains. Influenza causes the yearly flu, which infects 5–15% of the global population annually and causes 3-5 million severe cases worldwide.

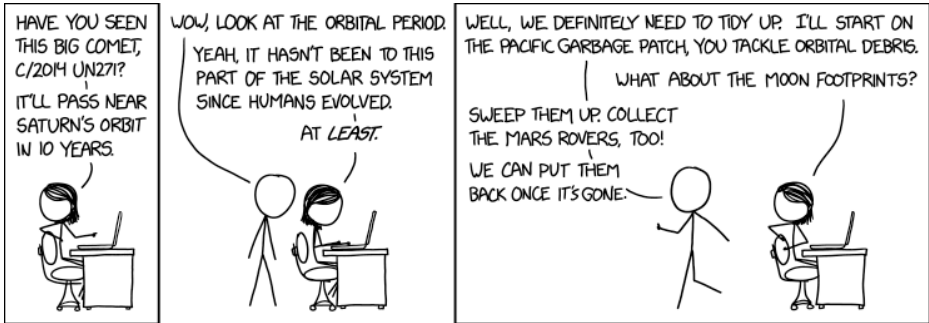
The bitter irony here is that much recent scholarship has described links between parasite biodiversity and ecosystem-wide, indeed planet-wide, biodiversity. In a few cases, if preserving and expanding biodiversity are seen as good things, then preserving and expanding biodiversity of parasites is a good thing, the one not being possible without the other. Parasites and disease agents, arguably, are classes of predators, and their removal can help establish a superpredator, the actions of which can catastrophically drive down biodiversity. Humans, released from predation by a large percentage of formerly-effective microbial predators, through the introduction of penicillin and other antibiotics plus other elements of 'heroic medicine', sanitation, etc., have

arguably become such a superpredator, and one that is mediating a loss of global biodiversity that may become the largest single species-extinction event in the history of planet Earth.

There also seems to be some evidence that infections with influenza viruses increase the chance of a heart attack. For instance regular flu shots reduce the risk of heart attacks. Thus the fact that we are "heartbroken" when B/Yamagata goes extinct could be sarcastic since we might suffer less from broken hearts.

#2524: Comet Visitor

October 04, 2021



It's a myth that the Great Wall of China is the only human-made structure visible from space--there are LOTS of structures for us to feel self-conscious about!

Explanation

Comet C/2014 UN271 is a large comet that was discovered in 2014 almost as far from the Sun as the orbit of Neptune, and it will reach its closest approach in 2031, near Saturn's orbit. It's an Oort Cloud comet, with a period of more than 4 million years. Since modern humans (*homo sapiens*) evolved about 300,000 years ago (although tool-making ancestors were around about 2.5 million years ago), the last time it was among the planets was indeed long before humans evolved.

When a long-period comet comes into the inner Solar System, it's often figuratively called a "visit". But Megan and Cueball treat this more literally (or perhaps more sarcastically). Just as one usually neatens up their home when they're expecting guests, to make a good impression, they realize they need to clean up the Earth and its vicinity in preparation for this "visitor". Cueball starts handing out assignments -- he'll clean up the Pacific Garbage Patch, and suggests that Megan take care of all the debris in orbit.

Cueball and Megan also make notes to sweep up the lunar footprints that NASA astronauts left on the Moon during the Apollo missions and put away the Mars rovers. It's also common for people expecting visitors to put various objects out of view with the intention of returning them to their normal place after the visit, usually because the objects are considered unsightly that under normal circumstances is outweighed by the

convenience of being out in the open.

However, since the comet will not come anywhere close to Earth and Mars, all this hardly seems necessary; it would be like cleaning up your home because the President or some other dignitary will be visiting your town. In addition, while a dignitary would theoretically be able to see one's house, although comets have tails, they do not have eyes,[citation needed] so they would not be able to perceive any difference between Earth before and after tidying up (even if the nucleus had an eye, it would not be able to see because it is in a coma, no pun intended). Furthermore, sweeping footprints in the Moon, that Cueball sees as a way of tidying up, would be seen as destroying an invaluable archaeological sites by NASA and other people.

Alternatively, Megan and Cueball aren't "cleaning up" for a visitor as one might do if the visitor was a friend of theirs. They're hiding themselves and contraband as one might do if they were worried the police were visiting. Or more likely in this context that it could be an alien visit, and they would like to make it difficult to spot the human civilization from space. In that case they might need to shut down all light in every big city on Earth as well.

The title text debunks the claim that the Great Wall of China is the only human-made structure visible from outer space; in fact the Great Wall cannot easily be distinguished from space (as it is very long but not wide), but some other human constructions such as the

Pyramids can (and cities are easily visible at night because they emit light).

#2525: Air Travel Packing List

October 06, 2021

AIR TRAVEL PACKING LIST

IF YOU HAVEN'T FLOWN IN A WHILE, YOU MIGHT NOT REMEMBER WHAT YOU NEED TO BRING. USE THIS HANDY CHECKLIST TO PACK!

- | | |
|--|--|
| <input type="checkbox"/> SEAT CUSHION | <input type="checkbox"/> HOMING BEACON |
| <input type="checkbox"/> PARACHUTE | <input type="checkbox"/> METEORITE ANTIDOTE |
| <input type="checkbox"/> WING GLUE | <input type="checkbox"/> USB WING CONNECTOR |
| <input type="checkbox"/> AIR HORN | <input type="checkbox"/> EMERGENCY SIREN |
| <input type="checkbox"/> SEXTANT | <input type="checkbox"/> SPARE FLAPS |
| <input type="checkbox"/> NOSE PLUGS AND GOGGLES
FOR PRESSURE | <input type="checkbox"/> MOUTHPIECE (PANDEMIC
RESTRICTION; AIRLINES STILL
PROVIDE THE TRUMPET) |
| <input type="checkbox"/> AIRPLANE SHOES | <input type="checkbox"/> LUGGAGE BALLAST |
| <input type="checkbox"/> NAVIGATION CRYSTAL | <input type="checkbox"/> FLAG (INTERNATIONAL FLIGHTS) |
| <input type="checkbox"/> SPARE BATTERIES IN CASE
THE PLANE RUNS OUT | <input type="checkbox"/> DECOY TICKETS |
| <input type="checkbox"/> BIRDSEED | <input type="checkbox"/> KEYS TO THE PLANE |

I know the etiquette is controversial, but I think it's rude when the person in front of me reclines their seat into the bell of my trumpet.

Explanation

This comic is another in a series of comics related to the COVID-19 pandemic.

The comic is about a proposed air-travel packing list, and the humor stems from the fact that many people have not been flying during the pandemic, and thus they might have forgotten what to pack. So Randall is so kind as to provide a packing list with 20 items. However, apart from the first item, the rest is not something you would or even should normally bring on an airplane.

Many of the items are already found on passenger airplanes, some items would seem like they could be useful on a plane, while others could actually be useful in case of a plane crash (but only if you survive), while many others would be counter-productive to safe air travel, even in the event of a crash. Below in the table is a quick summary of each item.

The title text references the idea that there is a trumpet for each passenger provided by the airline, which is item number 16 on the list. This item also states that you, because of the COVID-19 pandemic, should remember to bring your own mouthpiece for the trumpet as a safety measure.

The trumpet idea is then combined with the common debate regarding reclining your seat in airplanes. About half of the people think that reclining is rude as it takes

up the space of the person behind you. The other half think that seats recline for a reason and the person in a seat has the rights to the space behind them. See for instance this video about such a debate. Reclining a seat has resulted in actual physical fights on board airplanes.

Here it seems that Randall sides with the anti-recliners, although maybe only in the context of the comic, because he states that reclining would prevent him from playing his trumpet, as the seat hits the bell of the trumpet. The person in front could certainly argue that playing the trumpet behind them would be very annoying, to which Randall could reply that because the trumpet is provided by the airline, he has the right to play it. This would add a new layer to the debate. This could also be Randall's way of arguing against the right to recline a seat, just because it is possible.

Table of items[edit]

#2526: TSP vs TBSP

October 08, 2021

COOKING TIPS: TSP VS TBSP

TSP

TERASPOON

1,000,000,000,000

(10^{12}) SPOONS

TBSP

BINARY TSP

1,099,511,627,776

(1024^4) SPOONS

It's like one teraspoon / when all you need is a kilonife

Explanation

This is another one of Randall's Tips, this time a Cooking Tip.

This comic plays a joke on the common liquid measurements of teaspoons (tsp) and tablespoons (tbsp), which are commonly confused. In the US, a teaspoon is defined as 4.9 ml (0.18 imp fl oz; 0.17 US fl oz) while a tablespoon is defined as 14.8 ml (0.50 US fl oz; 3 tsp).

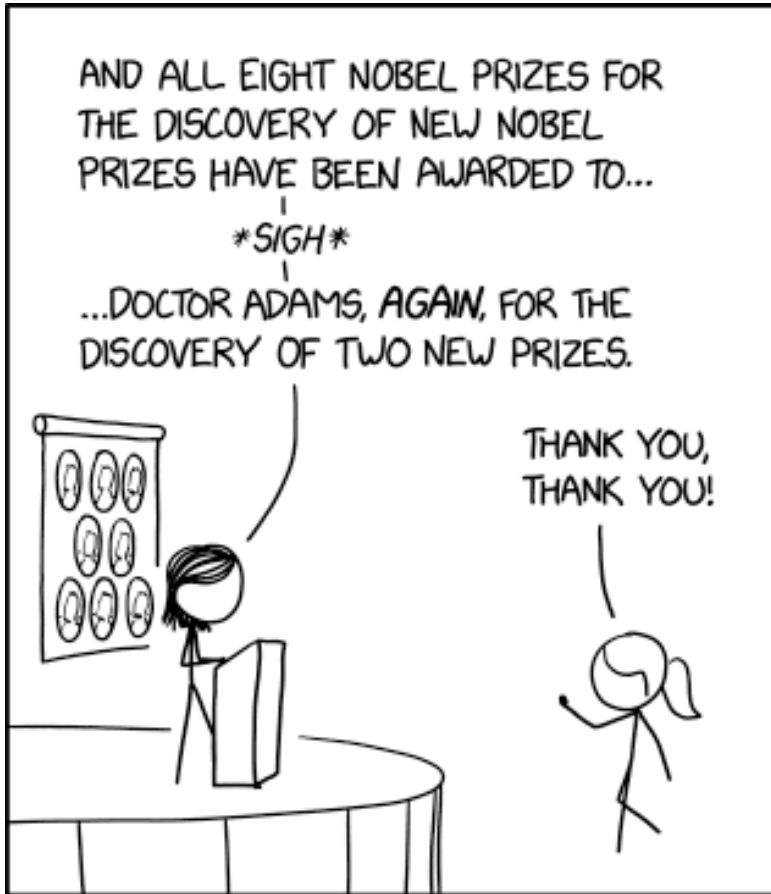
It also plays a joke on metric prefixes (based on powers of 10) versus binary prefixes (based on powers of 2), which are also a common source of confusion (see also 394: Kilobyte). In the International System of Units (SI), T (for tera-) signifies a multiplier of 10^{12} (that is, 1 000 000 000 000), while Ti (tebi-, for terabinary), and not Tb, is an ISO standard binary prefix meaning 2^{40} (that is, $1024^4 = 1\,099\,511\,627\,776$).

If "spoon" is understood as US teaspoon, then one teraspoon will be 4 928 922 cubic meters (1.302 billion US gallons or 3996 acre-feet) and a binary teraspoon will be 5 419 407 cubic meters (1.432 B gal or 4394 acre-ft). If the US tablespoon is taken as base unit, a teraspoon will be 14 786 765 cubic meters and a binary teraspoon 16 258 220 cubic meters – roughly equivalent to six thousand Olympic-size swimming pools or slightly more than six times the volume of the Pyramid of Giza. All these units have fairly limited uses in cooking.[citation needed]

The title text is a play on a lyric from the Alanis Morissette song "Ironic": "It's like ten thousand spoons when all you need is a knife." Randall changes the line to "teraspoon" and "kilonife". The "kilonife" comes from knife being interpreted as "nife" with a k prefix – k being the SI symbol for kilo- –, in a similar vein as taking tsp for "teraspoon". "Nife" is a geophysical name for Earth's core, thought to be composed of nickel and iron, and hence the word comes from the chemical symbols Ni (nickel) and Fe (iron).

#2527: New Nobel Prizes

October 11, 2021



WE DON'T KNOW HOW SHE STARTED THIS AND
NOW WE CAN'T FIGURE OUT HOW TO STOP HER.

They've endowed a separate prize in Physiology or
Medicine or Stopping Dr. Adams.

Explanation

The Nobel Prize is a set of prizes awarded in memory of Alfred Nobel to, "those who, during the preceding year, have conferred the greatest benefit to humankind."

In this comic a Nobel prize is being awarded for the discovery of two new Nobel prizes. This parallels Nobel Prizes awarded for the discovery of new elements. However, unlike elements, Nobel Prizes cannot be discovered.[citation needed]

The comic suggests that the doctor, presumably a social psychologist and the world's top expert on Impostor Syndrome, being awarded the prize came up with the idea of "discovering" Nobel Prizes, and no one can figure out how to stop awarding them to her.

In reality, the categories were established by Alfred Nobel's will for contributions or discoveries in the fields of Physics, Chemistry, Physiology or Medicine, Literature, and Peace. In 1968, Sweden's central bank funded an award for economics in honor of its 300th anniversary that is also colloquially called the Nobel Prize in Economics. While there is currently a petition to add a Nobel prize for contributions to environmental conservation, it would presumably also need external funding, although the decision process is unclear.

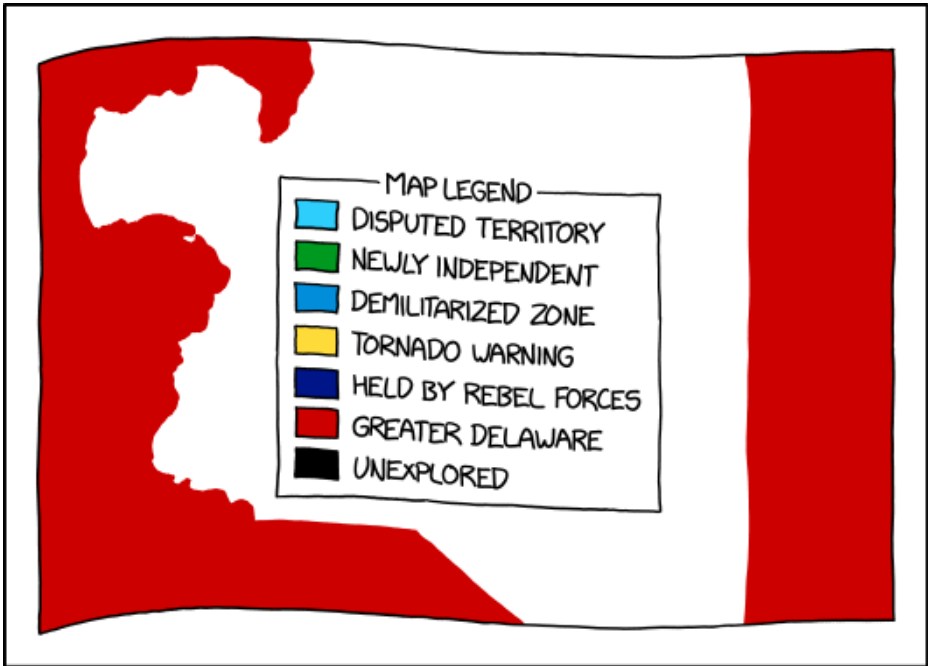
The title text is a play on the Nobel Prize in Physiology or Medicine, insinuating that the Nobel Assembly (the group in charge of awarding Nobel Prizes) has become so

desperate to stop Doctor Adams that they have decided to award a Nobel Prize to anyone who can make her stop 'discovering' new prizes. The joke also plays on the name of the said prize, because as of the writing of this comic the Nobel Prize in Physiology or Medicine is the only Nobel Prize with two subjects (i.e. with "or" in the title). This may also be a jab by Randall at the fields of Physiology and Medicine, as poking fun at other disciplines is a recurring theme on xkcd. [citation needed]

This comic was published on the Monday the week following the announcements of the 2021 Nobel Prize recipients.

#2528: Flag Map Sabotage

October 13, 2021



OUR NEW COUNTRY'S FLAG SABOTAGES THOSE MAPS WHERE
GEOGRAPHIC AREAS ARE COLORED IN WITH FLAG PATTERNS.

Delaware hopes to explore the western edge of areas
marked with the Belgian flag, once the tornadoes die down.

Explanation

The comic refers to a type of map that colors countries using the national flag designs; see here for such a map of Europe. Randall proposes a new flag specifically designed to troll such maps. Most obviously, the flag includes a legend with multiple common flag colors to indicate random regional attributes. Hence, the mere act of placing this flag on a map would cause people to misinterpret this legend as applying to the entire map, giving wildly false information about regions of other countries. This trick is reminiscent of 327: Exploits of a Mom, with Mrs. Robert's son named Robert'); DROP TABLE Students;--.

In addition to the legend, the flag consists of two red fields, one of which has an irregular-shaped border, the other of which is a straight line. The irregular shape is similar to a geographical border based on natural features (such as rivers and coastlines), while borders not based on such features tend to be straight lines. Red is the most common color on national flags, so if any bordering country had red on their flag, it would risk bordering these red fields, confusing where the border lay (as well as designating the entire red region as "greater Delaware"). If this flag is intended for the USA (although the text mentions "our new country"), the red regions would be continuous with the red strips on both sides of Canada's flag and the red field on the right of Mexico's flag, disguising the border still further.

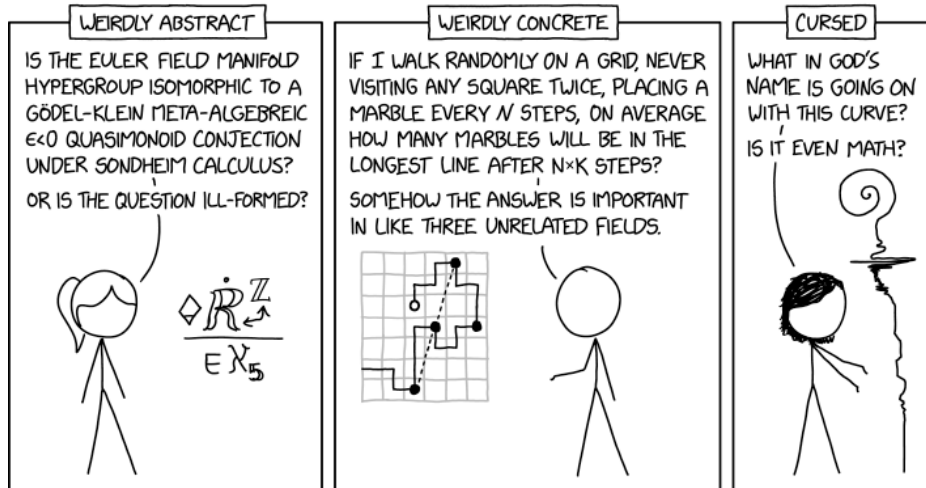
The title text refers to the flag of Belgium, which consists of three vertical stripes in the order (left to right) black, yellow, and red. The western part of Belgium would, according to the legend, be unexplored, while the eastern part would be Greater Delaware. The middle would therefore be a tornado zone separating the unexplored area from Greater Delaware. Depending on how the flags are aligned it might be possible to explore from the south, where the blue-white-red stripes of the French flag contain another piece of Greater Delaware that may be conveniently located to help said exploration. Exploring from the Netherlands (red, white, and blue horizontal stripes) is not viable as rebel forces are positioned between Greater Delaware and the unexplored region.

This is not the first time Randall has made a flag for a new country.

#2529: Unsolved Math Problems

October 15, 2021

THE THREE TYPES OF UNSOLVED MATH PROBLEM



After decades of studying the curve and the procedure that generates it, the consensus explanation is "it's just like that."

Explanation

Math has many problems that remain "unsolved." This is not simply a matter of finding the correct numbers on both sides of an equal sign, but usually require proving or finding a counterexample to some conjecture, or explaining some property of some mathematical object. Sometimes this might involve extending an existing proof to a wider range of numbers like reals, complex numbers, or matrices.

A concrete problem is one that is very obviously connected to a real world process, while an abstract problem is one which seems unconnected to actual problems. In modern math, many problems tend to be very abstract, requiring complicated notation to adequately state the problem in the first place, like many of the millennium problems. On the other hand, many unsolved problems are very concrete, such as the Collatz conjecture. Additionally, there are the many problems related to packing objects into spaces which are often very difficult to solve though quite easy to state. Finally, Randall describes a third category of "cursed problems," that have strange, seemingly random behavior, such as the behavior of turbulence or the distribution of prime numbers.

In the first panel, Ponytail describes a weird abstract problem. Her description seems to be a meaningless jumble of terms that are either mathematical or just sound mathematical. And the mathematical terms are

from disparate branches of mathematics: group theory, topology, and calculus.

- Euler field: An Euler vector field represents a space where every point is rotating with its own speed and direction. The name "Euler field", however, is something like "John Smith" - fields are very common algebraic structures, and Leonard Euler was a prolific Swiss mathematician who influenced so many areas of study that some of his discoveries are named after whoever wrote about them next, just to avoid naming everything after him.
- Manifold: A manifold is a topological space which is locally Euclidean - the shortest distance between two points is a straight line, the ratio between a circle's circumference and diameter is always pi, parallel lines are always the same distance apart, everything generally behaves the way you'd expect. A globe is a two-dimensional manifold, because a small-enough area is indistinguishable from a flat map. Using manifolds as an example of impenetrably occult maths may be a nod to the Tom Lehrer song "Lobachevsky", which makes a similar joke about "the analytical algebraic topology of locally Euclidean metrizations of infinitely differentiable Riemannian manifolds (Bozhe moi!)".
- Hypergroup: An algebraic structure, like arithmetic, is a set of well-defined operations (addition, subtraction, multiplication, division) mapping inputs to outputs over a domain of elements (the real numbers). A hyperstructure is an algebraic structure including an

operation that maps a single input to multiple outputs - the simplest example is the square root, which maps a positive number like 4 to both positive and negative 2. A hypergroup is a hyperstructure with an operation that takes a pair of input elements, and, depending on which pair, can output every element or combination of elements in its domain... but also preserves association ($1 + 2 + 3 = 6$ whether you start by adding $1 + 2$ or $2 + 3$) and reproduction (if either input is "the entire domain", then the output will still be the entire domain). It's a decent indication of how abstract a hypergroup is that it takes at least three to five sub-definitions to make it remotely understandable.

- Isomorphic: Isomorphism describes whether all the attributes of one structure can be mapped to properties of another structure. The structures usually have to be of the same type; it is unclear how a hypergroup would map to a "conjection".
- Gödel-Klein: Kurt Gödel was a 20th-century mathematician who studied logic and philosophy (he's most well known for Gödel's incompleteness theorems) and Felix Klein was a 19th century mathematician who studied group theory and geometry; the two probably never collaborated.
- Meta-algebra: Not a real term, though derived from the real term Metamathematics.
- <0 : Another joke term. In analysis, is usually defined to be an arbitrarily small positive number.
- quasimonoid: A malamanteau, combining the prefix

"quasi" (meaning "partially" or "seemingly") and "monoid" (an object from group theory) and is probably meant to evoke the character Quasimodo from *The Hunchback of Notre-Dame* (although quasimonoids are a type of algebraic object, namely a non-associative monoid)

- **Sondheim Calculus:** This refers to Stephen Sondheim, one of the most successful composers and lyricists of American musical theatre -- the producer of his musical *"Into the Woods"* once remarked that "Singing Stephen Sondheim is like calculus for singers and actors."
- **conjection:** This may combine conjecture and conjunction, or be a joke on pros and cons plus projection.

Finally she asks whether the problem statement is ill-formed; considering that it's mostly gibberish, this may be true.

Many real unsolved math problems appear similarly abstract. One example is the Hodge conjecture, a Millennium Prize problem. It states "Let X be a non-singular complex projective manifold. Then every Hodge class on X is a linear combination with rational coefficients of the cohomology classes of complex subvarieties of X ." These words may appear nonsensical to a layperson. And even to an expert, the question is 'abstract'. (Given a specific manifold, even an abelian fourfold, how on earth do you determine if a given $2,2$ class is a cycle?)

In the second panel, Cueball describes a concrete random walk problem, and then mentions that this somehow has applications in three unrelated fields. This is actually not uncommon. The Wikipedia article says that "random walks have applications to engineering and many scientific fields including ecology, psychology, computer science, physics, chemistry, biology, economics, and sociology. Walking randomly on a grid never visiting any square twice is known as a self-avoiding walk." This panel may have been inspired by some of the tricky unsolved problems about self-avoiding walks. Many of these problems have to do with rigorously proving properties of random walks that have been guessed by physics intuition, so these problems are connected to physics. The part about the maximum number of points in a line is reminiscent of problems in combinatorial geometry, which often involve counting points lying on different lines. Python code simulating this situation can be found [here](#). C++ code simulating this situation can be found [here](#).

In the final panel, Megan is looking at a strange curve that seems to have no consistent pattern. At the bottom it's mostly straight, with a few little wobbles. In the middle it looks like a wild, high-frequency wave that suddenly bursts and then dies down. And the top is a spiral that looks like a question mark or a Western-style Crosier. She wonders if this could even be mathematical.

On one hand, considering the weird shapes that come from plotting some mathematical processes (e.g. the Mandelbrot set, or the bifurcation diagram of the logistic

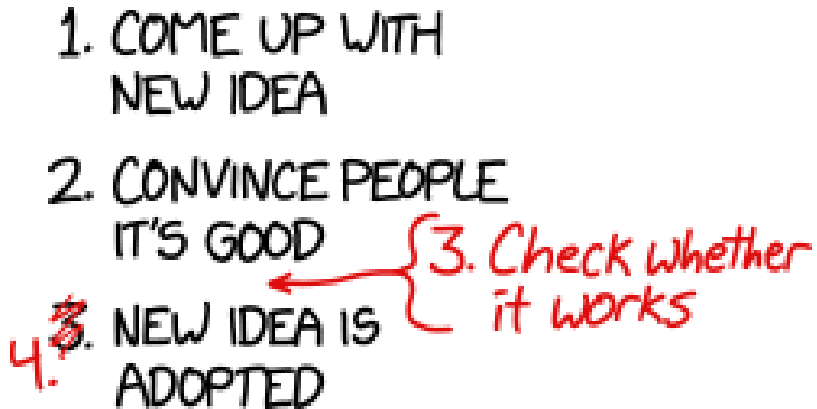
map), it could well be. For example the unsolved Riemann hypothesis, another Millennium Prize problem, concerns the properties of a weird and at-first-glance random curve. In number theory, the term "cursed curve" has been used to describe the "split Cartan" modular curve of level 13, which resisted attempts for many years to compute its set of rational points.

On the other hand, the question if could even be mathematical suggests that this may indeed not be a mathematical symbol. The curve looks like the unalome symbol, which is a Buddhist symbol which represents the path taken in life, or the journey to enlightenment. It could be argued that this indeed represents an unsolved problem, although not a mathematical one - which might then be part of the humoristic meaning.

The title text states that, despite decades of intensive study on the properties of the cursed curve, the best anyone's been able to come up with to explain its strangeness is "it's just like that." This lack of a satisfying explanation is commonplace with advanced math topics. As one famous example, the monster group (explanation video) is known to be the largest of a category of objects called sporadic groups. Similarly to the cursed curve in the comic, the monster group has a bizarre and complex structure which has, so far, managed to elude any logical explanation aside from "it's just like that."

#2530: Clinical Trials

October 18, 2021

1. COME UP WITH
NEW IDEA
 2. CONVINCE PEOPLE
IT'S GOOD
 3. Check whether
it works
 4. NEW IDEA IS
ADOPTED
- 

THE INVENTION OF CLINICAL TRIALS

We don't need to do a clinical trial of this change because the standard of care is to adopt new ideas without doing clinical trials.

Explanation

The comic begins with a simple process for adopting a new idea just by convincing people that it is a good idea. The joke is that this skips the important step of checking whether it actually is a good idea. That correction presumably comes about after ideas are adopted which sounded good but turn out to be harmful. The comic captions the addition of this checking step as "the invention of clinical trials".

The purpose of clinical trials in medicine is to make sure that a new medicine works and doesn't have serious side-effects. One example of the dangers of failing to make sure that it doesn't have serious side effects is thalidomide, which caused a lot of birth defects. In a clinical trial, the effect of a treatment is compared to the effect of a placebo, or an existing treatment, to make sure it actually has a beneficial effect. (Earlier trials establish that it is even a viable candidate for testing and establishing possible dosages/regimens that can then be carried forward to a treatment (Phase III) trial.)

Before the invention of clinical trials, people generally didn't know, or at least had no way of confirming, whether medicines actually worked. Although many herbs and medicines were effective, others were no better than a placebo, and some medical treatments such as trepanation and bloodletting not only had no benefit (except for a very few rare conditions) but were very likely to be harmful. Those treatments that did work at

all were mostly those that had been tried (for whatever reason) and just happened to be useful, but others had neutral or even adverse effects, but still managed to not be so dangerous that subsequent recoveries from the original ailment—regardless of (or despite!) dangers inherent in such treatments—were taken as proof of their efficacy.

Similar to more recent examples, some earlier treatments may have been gradually discovered to help a particular condition only by noticing beneficial side-effects when consumed for sustenance or for unrelated medical 'guesses'. However, they also remained without the full scientific rigour so long as it remained a 'traditional remedy' with at best an oral tradition across many disparate practitioners, and no consistent effort to formalise or test the falsifiability of any findings.

At the time that this comic was published, the world was in the middle of the COVID-19 pandemic, which made the existence of clinical trials more relevant to the public, who waited eagerly for what sounded like good ideas to get through clinical trials and available to the general public... or fail clinical trials and not do that. During this frustrating wait, many unscientific claims have been made that various drugs or non-drug treatments are cures for COVID-19, making it difficult to convince believers to get real treatments. On the other hand, many people were skeptical about COVID-19 vaccines which were made available to the public for emergency use before the clinical trials were finished, or had concerns about whether the clinical trials were rushed or otherwise

flawed due to how quickly they were conducted compared to the traditional speed for vaccine development and approval.

In the title text, "Standard of care" refers to the previously accepted practice which a new medicine needs to be compared against. Because the original 3-step "standard of care" in this comic didn't include clinical trials before their adoption, we didn't need to do any testing in order to decide to start using them. If we had had them as the standard of care, then we would have had to perform tests before we added a step and it would have taken longer. This assumes that the process itself is subject to the same scientific rigor as medical treatment; in practice that would be more of a political change that is still not tested.

This comic can be viewed to criticize several extreme political proposals that are obviously bad ideas to most people, such as abolishing the nuclear family, making gay marriage illegal, blocking the development of renewable energy sources and abolishing the police. People tested the latter in Seattle, and the test didn't go well.

#2531: Dark Arts

October 20, 2021



MY RESPONSE WHENEVER ANYONE ASKS
ME TO MESS AROUND WITH FILESYSTEMS

You think, 'okay, **THIS** is an ideal use case for hardlinks!' but then 6 months later you're doing some extremely cursed Google search like 'javascript ext4' and wondering where things went wrong.

Explanation

White Hat has presumably just asked Cueball to perform some task involving filesystems. Cueball responds with an exceptionally melodramatic monologue, referring to the subject as "dark arts" and stating he'd rather not have anything to do with them. This is reminiscent of a fairly typical scene in fantasy novels, superhero movies, etc: a person with supernatural powers explains they prefer not to use them, as their use is likely to have negative effects that outweigh the positive ones. Often this is tied to a tragic backstory of the character, where the use of their powers previously caused them or someone close to them much suffering.

The humor of the comic comes from the parallel drawn; it seems unlikely that knowledge of filesystems could have negative consequences on the scale of, say, leveling a city, so the comparison is hyperbolic. However, much of today's infrastructure does depend on legacy systems that can be very overly complex to work with, having weathered aggressive political conflicts and short corporate deadlines for decades now. An example is the recent shutdown of the pgp keyserver network, or how the developer of the fastest linux filesystem built (reiserfs) was imprisoned for murdering his wife right before it could be merged into linux. Still, this joke is in a similar vein to comics like 349: Success, in which Cueball's relationship with technology is shown to have a potential for disaster far exceeding that of a normal person's.

A filesystem is the part of a computer's operating system that handles the organization of data in persistent storage, usually splitting it into files and directories. It can be a very complicated piece of software. Because of this, it is easy to make mistakes in advanced usage, and because it controls practically all data on a given machine, mistakes made can have serious consequences (e.g., loss of data). These properties of filesystems are likely why Cueball is reluctant to mess with them.

ext4 is a popular filesystem used with the Linux operating system kernel.

Hardlinks allow two filenames to refer to the same underlying file or directory. These can be particularly tricky to use, as in nearly all respects they look like regular files, but modifying them can have effects that are not immediately obvious (e.g., changing what one filename refers to, the other will not remain consistent). Hardlinks and their misuse have been referenced in xkcd before, as in 981: Porn Folder.

The title text hints at an experience Cueball or Randall had (his own "tragic backstory", if you will), involving hardlinks on ext4. He thought he had found an ideal use case for them, one which presumably avoided most of their pitfalls, but still, six months later, ended up having to troubleshoot some inscrutable bug arising from his decision.

Javascript is a programming language most often associated with web pages. As such it is not usually

interacting directly with a computer's filesystem, since allowing arbitrary websites to access the filesystem is widely considered an extremely bad idea.[citation needed] It is possible to run Javascript directly outside of a browser – in which case it does have access to common filesystem operations, and even theoretically to the internals of the filesystem – but since it is a high-level language with poor support for working with the data structures a filesystem uses, this would be a painful, "cursed" way to go about things.

A senior IT professional (nowadays fewer people need to know about such features) will be reminded of their own experiences and mishaps with non-trivial file system configurations. Beyond hardlinks, filesystems may have a number of features a normal user or even an admin are not aware of. Such features are prone to bugs, poor documentation, or poor integration with other system tools.

For example:


- Symbolic links (soft links) - one file links to another using its name. While symbolic links work "everywhere," hardlinks are generally limited.
- Compressed filesystems can cause unexpected side effects in performance, quota management, and disk fragmentation.
- Sparse files and shallow copies (copy on demand).
- Live filesystem backup and file locking.
- Read-only filesystems.

- 'Virtual' filesystems, like memory-backed and file-backed file systems, backed by dynamic data or databases.
- 'Overlay' file systems where a read-only portion is overlaid and partially shadowed by another file system.
- File caching for read or write operation.
- Syncing file systems.
- Many, many more.

"In another age" might refer to the fact that detailed file system manipulations were common in the days when developers were installing, configuring and managing operating systems and software on physical servers. When disk space was limited and network speeds were low, such manipulations saved space and time. Virtualization, containerization and deployment frameworks isolate developers and administrators from such low level details.

#2532: Censored Vaccine Card

October 22, 2021

 CHECK IT OUT, I JUST GOT MY BOOSTER!

COVID- VACCINATION RECORD CARD

PLEASE KEEP THIS RECORD CARD, WHICH INCLUDES [REDACTED]
ABOUT [REDACTED]
POR FAVOR, GUARDE ESTA TARJETA DE REGISTRO, QUE INCLUYE [REDACTED]
[REDACTED] SOBRE [REDACTED]

MUNROE **RANDALL**
LAST NAME FIRST NAME
10-17-84 **41592653**
DATE OF BIRTH PATIENT NUMBER

VACCINE	MANUFACTURER LOT NUMBER	DATE	PROVIDER OR CLINIC SITE
1ST DOSE COVID- [REDACTED]	PFIZER ER1138	04/01/21 MM DD YY	CVS PHARMACY CLINICIAN #5309
2ND DOSE COVID- [REDACTED]	PFIZER ES2187	04/22/21 MM DD YY	CVS [REDACTED]
OTHER	3rd GSK [REDACTED] FH1729	10/21/21 MM DD YY	[REDACTED] CIA
OTHER	[REDACTED]	[REDACTED] MM DD YY	[REDACTED]

SECURITY TIP: TO SEEM MORE MYSTERIOUS, TRY
CENSORING ONLY *NON-IDENTIFYING* INFORMATION.

CVS's pharmacies are fine, but I much prefer their
[censored]s.

Explanation

This comic is another entry in a series of comics related to the COVID-19 pandemic, specifically regarding the COVID-19 vaccine.

The comic hinges on the sharing of vaccination card photos on social media as proof that the user has been vaccinated against COVID-19 (in this case, gotten a booster shot, a third dose of the vaccine). When people in the United States first started receiving their vaccine shots, a large number of them shared photos of the CDC vaccination proof cards that they received alongside the vaccines; it was enough of a trend that the FTC released an official statement warning vaccine recipients not to share photos, due to the cards containing personal identification that probably should not be made public.

The irony here is that Randall has "censored" (redacted) some impersonal lines, such as the instructions that are identical on all vaccination cards, and many easy-to-guess lines, while not censoring any of said personal information.

Considering the date of the 3rd dose (one day prior to the comic's uploading), it is likely that the blackouts in the last line are only covering whitespace.

Another possible reference here is to the practice of filing for FOIA requests that has been getting more popular in recent years, with sites like muckrock.com developing to support it. These requests provide for citizens to view

the contents of government files, but the files first go through a process of redaction via solid black rectangles. The information that is redacted can seem random, ridiculous, and frustrating, and be a source of legal action.

The caption indicates that his intention is to "seem more mysterious". This is best exemplified by the blanking of most of the word "clinician" to leave the acronym "CIA", referring to the US government agency known for its frequently "mysterious" (classified) activity, as well as its liberal use of redaction like that in the comic.

The "19" in COVID-19 is systematically censored in the comic. This is humorous because currently COVID-19 is the only thing that could be meant by "COVID-[anything]", and so the redaction is pointless. This may also be intended, in the interest of mystery, to imply some future outbreak of a similar disease (given an identifier based on the year of its inception).

The sentence at the top of the card, which appears once in English and once in Spanish, has equivalent portions redacted in both languages:

- "medical information" and "the vaccines you have received" in the English version, and
- "información médica" and "las vacunas que ha recibido" in the Spanish.

This is one of the comics (another being 1434: Where Do Birds Go) including a sentence (or, given the censorship,

at least a good portion of one) in Spanish.

CVS Pharmacy is a pharmacy chain in the US which provides COVID-19 vaccinations. CVS #05309 is in Pineville, LA, while Randall lives in Massachusetts; it is not clear why he would have received his first vaccine dose in Louisiana.

The title text comments on the "Provider or clinic site" of the second dose on the card. Where the word "pharmacy" appears in the previous row (and would be on a real card), it is censored in the comic. The most reasonable assumption is that the word is still "pharmacy" and that Randall has simply chosen to redact that instance for some reason, but the title text humorously implies that it was in fact some other CVS-related venture where he got his second dose, for instance a "CVS parking lot" or perhaps an anti-submarine warfare carrier.

CVS's parent company, CVS Health, does have other enterprises with compatible names: CVS Caremark and CVS Specialty. However, neither of these provide COVID-19 vaccinations.

Numerical trivia[edit]

Randall's patient number is the 2nd to 9th digits of the fractional part of the decimal expansion of pi inclusively: 41592653.

The lot numbers of the first and second doses allude to two numbers that appear frequently in Star Wars and other works related to George Lucas: 1138, and 2187. Forty comics later, in 2572: Alien Observers, THX 1138 is also indirectly referenced in

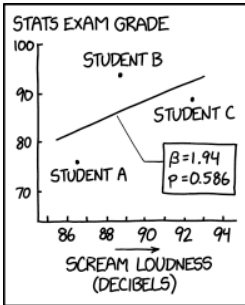
the number of one of the humans mentioned. The lot number of the third dose is the Ramanujan-Hardy number.

The Clinician number for the first shot is the last 4 digits of the phone number for "Jenny" 867-5309, which has been entered into communication technology by a massive number of people.

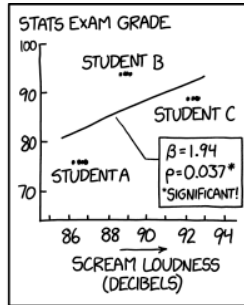
Given the reasonable assumption[citation needed] that the partially censored year relates to the twentieth century, the date of birth on the card corresponds to that given in the acknowledged timeline for Randall. The censorship of that specific part of his date of birth might be related to the fact that the number "19" has been systematically redacted on the card. Another interpretation is that Randall is implying he is either over one hundred years old or a time traveler, although neither is likely to be true.[citation needed]

#2533: Slope Hypothesis Testing

October 25, 2021



DARN, NOT SIGNIFICANT.
WE NEED MORE DATA.
HAVE THEM EACH TRY
YELLING INTO THE MIC
A FEW MORE TIMES.



PERFECT!

ARE YOU SURE
WE'RE DOING
SLOPE HYPOTHESIS
TESTING RIGHT?



"What? I can't hear--" "What? I said, are you sure--" "CAN YOU PLEASE SPEAK--"

Explanation

"Slope hypothesis testing" is a method of testing the significance of a hypothesis involving a scatter plot.

In this comic, Cueball and Megan are performing a study comparing student exam grades to the volume of their screams. Student A has the worst grade and softest scream, but Student B has the best grades and Student C the loudest scream. A trendline has been plotted, indicating a positive correlation between grades and volume...but the p-value is extremely high, indicating little statistical significance to the trend. P-value is based on both how well the data fits the trendline and how many data points have been taken; the more data points and the better they fit, the lower the p-value and more significant the data.

Megan complains about the insignificance of their results, so Cueball suggests having each student scream into the microphone a few more times. (The three students are still there as they can be seen behind them. The three students look like schoolkids; one of them is Jill.)

Having the students scream again will not help though, because it only provides more data on the screaming without providing more data on its relation to exam scores and is a joke around poor statistical calculations likely made in the field today. The p-value is incorrectly recalculated based on the increased number of

measurements without accounting for the fact that observations are nested within students. Each student has exactly the same test scores (probably referencing the same datum as before) and have vocal volume ranges that don't drift far either (each seems to have a range of scream that is fairly consistent and far from overlapping). Megan is pleased by these results, but Cueball belatedly realizes this technique may not be scientifically valid. Cueball is correct (presuming that they are using simple linear regression). A more appropriate technique would account for the non-independence of the data (that multiple data points come from each person). Examples of such techniques are multilevel modeling and Huber-White robust standard errors.

Measuring data multiple times can be a way to increase its accuracy but does not increase the number of data points with regard to another metric, and the horizontally clustered points on the chart make this visually clear. A more effective and scientifically correct way of gathering data test would be to test other students and add their figures to the existing data, rather than repeatedly testing the same three students.

Common statistical formulae assume the data points are statistically independent, that is, that the test score and volume measurement from one point don't reveal anything about those of the other points. By measuring each individual's scream multiple times, Cueball and Megan violate the independence assumption (a person's scream volume is unlikely to be independent from one scream to the next) and invalidate their significance

calculation. This is an example of pseudoreplication. Furthermore, Megan and Cueball fail to obtain new test scores for each student, which would further limit their statistical options.

Another strange aspect of their experiment is that the p-values obtained during a typical linear regression assume there is uncertainty in the y-values, but the x-values are fully known, whereas in this experiment, they are reducing uncertainty in the x-values of their data, while doing nothing to improve knowledge of the y-values.

Moreover, even if the new data were statistically independent, this still appears to be a classic example of "p-hacking", where new data is added until a statistically significant p-value is obtained.

In current AI, there's a push toward "few-shot learning", where only a few data items are used to form conclusions, rather than the usual millions of them. This comic displays danger associated with using such approaches without understanding them in depth.

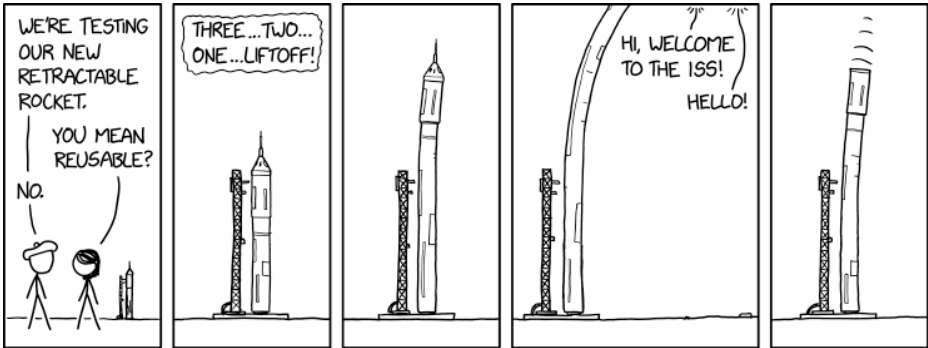
Additionally, a common theme in some research is the discovery of correlations that do not survive independent reproduction. This is because randomness with too few samples produces apparent correlations, and Randall has repeatedly made comics about this hopeful error (see 111, 925 and 882 among others).

In the title text, Megan and Cueball are trying to yell over

each other, asking each other to speak up so they can be heard; they are presumably suffering tinnitus or other hearing problems after listening to so much shouting.

#2534: Retractable Rocket

October 27, 2021



Hard to believe that for so many years once they were fully extended we just let them tip over.

Explanation

This comic documents another of Beret Guy's absurdist ventures. He explains to Megan that "we" (possibly his company) are testing their new "retractable" rocket.

Reusable rockets are a growing industry, as they are more economically viable in the long run – though technically much more difficult to operate – than rocket boosters that are just discarded after use (which have been standard throughout the majority of space-faring history). Thus, Megan is understandably confused about Beret Guy's assertion that theirs is "retractable", asking if he misspoke. In typical fashion, he assures her that he did not misspeak, with a single "No" without further explanation.

They proceed to watch the rocket "launch", proving that it is indeed retractable. In fact the rocket does not launch, but merely extends – apparently all the way to the International Space Station (ISS), a height of over 400 km (over 250 miles) – before retracting, as promised, to its original position. The top part, with the astronauts in it, has been left in space. Presumably, it is docked to the ISS, as the crew onboard the ISS welcome them in panel 4.

Of course, it would not be possible to magically extend a rocket this far.[citation needed] The top would need to be moving very fast compared to the bottom part, or it would bend westwards and break, and even with the

strongest material a fully extended, very thin, presumably, hollow structure with a payload on top would buckle very soon after extension began. Also, the ISS moves at 27,600 km/h (17,100 mph) compared to the ground under it, making an orbit in about one and a half hours. So making the tip follow this long enough to dock would be even more impossible.

Beret Guy's retractable rocket has more than a few similarities to a space elevator which has been discussed in real life. The chief difference is, a space elevator is only extended once (and most likely this would be down from space, not extended upwards), and never retracted unless it needs to be dismantled. Randall has referenced space elevators in 697: Tensile vs. Shear Strength. A more similar theoretical means to attain orbit is that of the space fountain. He has also examined the problems of a solid metal object extending through the atmosphere in a what-if.

The current method of sending rockets into space requires huge amounts of fuel, and the more fuel you attempt to carry, the heavier the rocket, leading to more fuel being required, etc. (Tsiolkovsky rocket equation), which makes the current method inefficient. Alternate methods are being explored, such as using a slingshot (SpinLaunch had a successful test flight of a smaller scale launcher just days before this comic was published, probably the influence for this comic), theoretical space elevators, or this comic's impossible retractable rocket idea, all of which would leave the majority of the "fuel" requirements on Earth or elsewhere rather than having to

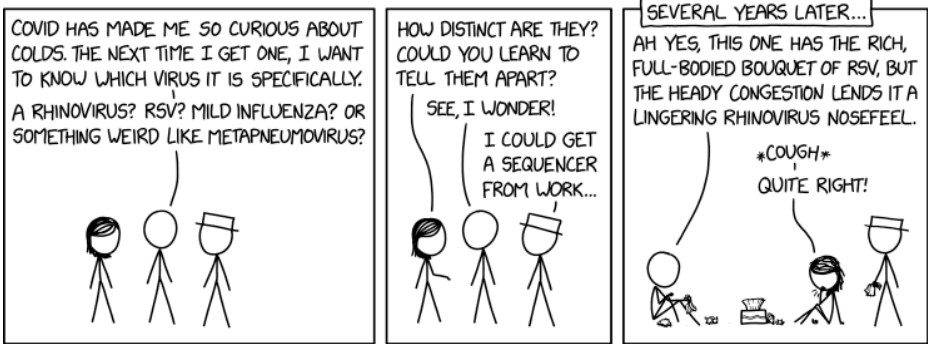
carry heavy fuel with the rocket. The only fuel carried might be minimal amounts for course adjustments once in space rather than large amounts used to get there. However, many of these methods are less flexible than rockets; the space elevator, for instance, operates on the basis of constant angular velocity relative to the Earth's axis of rotation, meaning that it cannot launch payloads directly into low-earth orbit, polar orbits, or many other orbits frequently used by satellites for their desirable characteristics, and satellites intended for these orbits might still need to carry considerable amounts of fuel, even if less than that required to launch directly from the ground.

The title text parodies the 'old' single-use boosters. It appears that the predecessors to the 'retractable rockets' were capable of controlled extension only. Once they had lofted the payload to orbit, they were then allowed to fall over, destroying them in the process so they could not be used again just like booster rockets. However, if a 250 mile/400 km high construction just fell over, it would be much more difficult to avoid other damage, than to the rocket (booster), than for just a few small booster rockets falling out of the sky.[citation needed]

This comic was released four days before (and possibly refers to) SpaceX's Crew-3 mission to send astronauts to ISS with a reusable rocket on 31 October 2021.

#2535: Common Cold Viruses

October 29, 2021



"It's not an influenza, but the onset has notes of the '09 H1N1 strain." "Ah yes, that was a good year for H1N1."

Explanation

This comic is another entry in a series of comics related to the COVID-19 pandemic.

In this strip, Megan and White Hat are listening to Cueball explain his newfound interest in the various different viruses that cause the common cold, which is an umbrella term used to describe the mild-to-moderate symptoms these viruses all cause.

Megan expresses curiosity as well, and White Hat suggests he could get a DNA sequencer to help. By the third and final panel, several years have passed. All three characters appear to be ill, perhaps even as a result of now purposefully infecting themselves with chosen diseases. Whether deliberately or 'naturally', they do seem to have by now encountered a respiratory syncytial virus (RSV) and various types of rhinoviruses, and are now describing their experienced symptoms with terms similar to ones used in wine tasting (e.g. "bouquet" is a term used in wine tasting; "nosefeel" is a parody of the wine-tasting term "mouthfeel", etc.).

This strip follows the theme of 915: Connoisseur, making fun of the fact that people can form strong opinions and preferences on pretty much anything if they spend enough time and attention on it. In this case, despite the fact that the symptoms of these viruses are almost universally considered to be unpleasant, the characters appear to have developed an appreciation for

the subtle variations. A similar phenomenon is referenced in 1095: Crazy Straws.

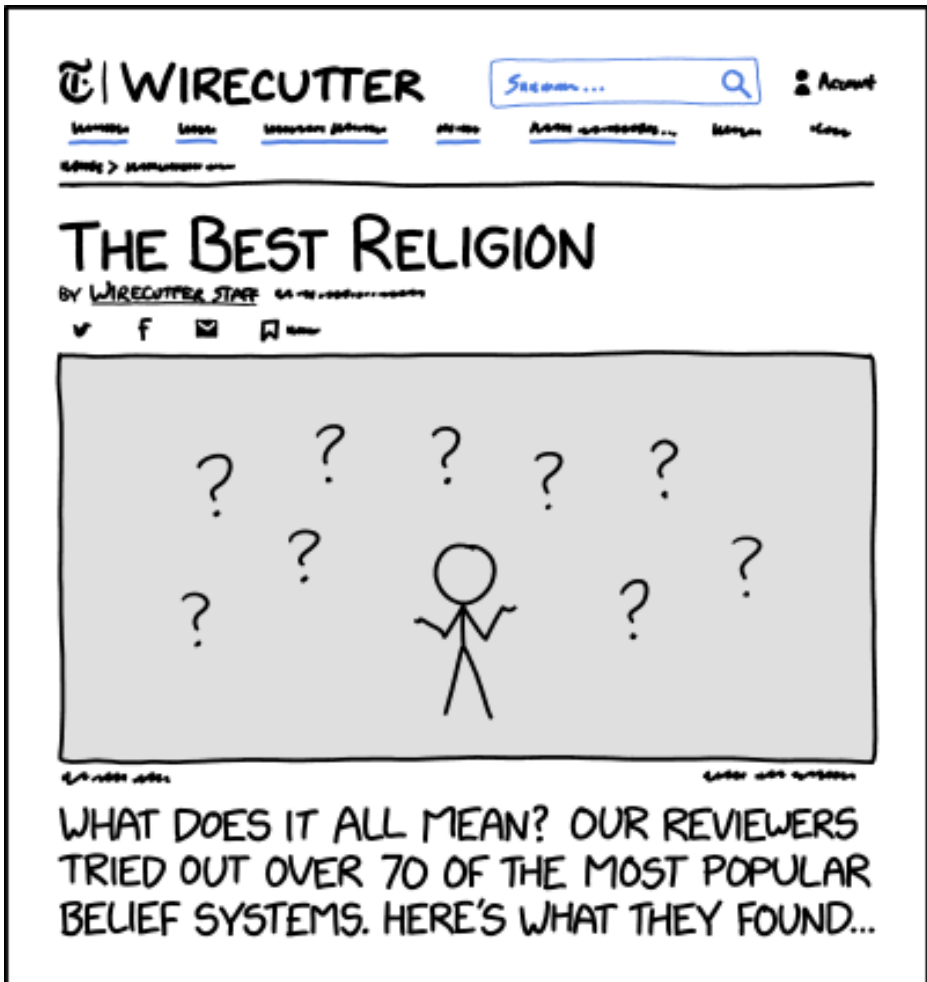
The idea of intentionally infecting a person with a disease is a trope in multiple Speculative Fiction stories. For instance, Iain M. Banks' Culture series, set in a world where all diseases are eradicated or treatable, includes story lines where individuals deliberately infect themselves with viruses to experience the symptoms.

The title text references the H1N1 swine flu virus, which was the disease at the heart of the 2009 swine flu pandemic. It also further expands on the wine tasting comparison – connoisseurs often consider the environmental conditions of the growing season the grapes came from as an important factor in the quality of a given wine, so certain years may be considered better than others. Since 2009, less severe forms of H1N1 influenza have become one of the standard variants in annual flu seasons and a perennial in the influenza vaccination mix. From the influenza strain's perspective, 2009 was the year of breakthrough success for H1N1.

As access to community makerspaces, labs, and knowledge has spread, people have begun doing more things at home that were previously confined to industrial and academic research environments. This was stimulated further during the onset of the pandemic, when communities became focused on helping offset overtaxed national resources.

#2536: Wirecutter

November 01, 2021



This was always going to be a controversial Wirecutter post, but what really got them in trouble were their 'budget' and 'upgrade' picks.

Explanation

Wirecutter is a product review website owned by The New York Times. Randall is parodying the website by having them "review" the 70 most popular religions. Product review websites typically make posts with the "best" X, e.g. "Best smartphones," or "Best laptops." These reviews are useful for consumers trying to choose among the wide variety of products available.

There are a wide variety of religions. However, unlike electronic devices, a person does not usually choose their religion; they are typically taught one during childhood and most remain in that religion their entire life. Changing religions is (usually) a significant life event. Many religions, including many variants of the three major Abrahamic religions promote exclusivity, and do not recognize other religions as valid. They emphasize the importance of specific practices or belief in specific creeds. Members of those religions might not recognize a reviewer as having truly "tried" their religion if their intent was always to move on to another.

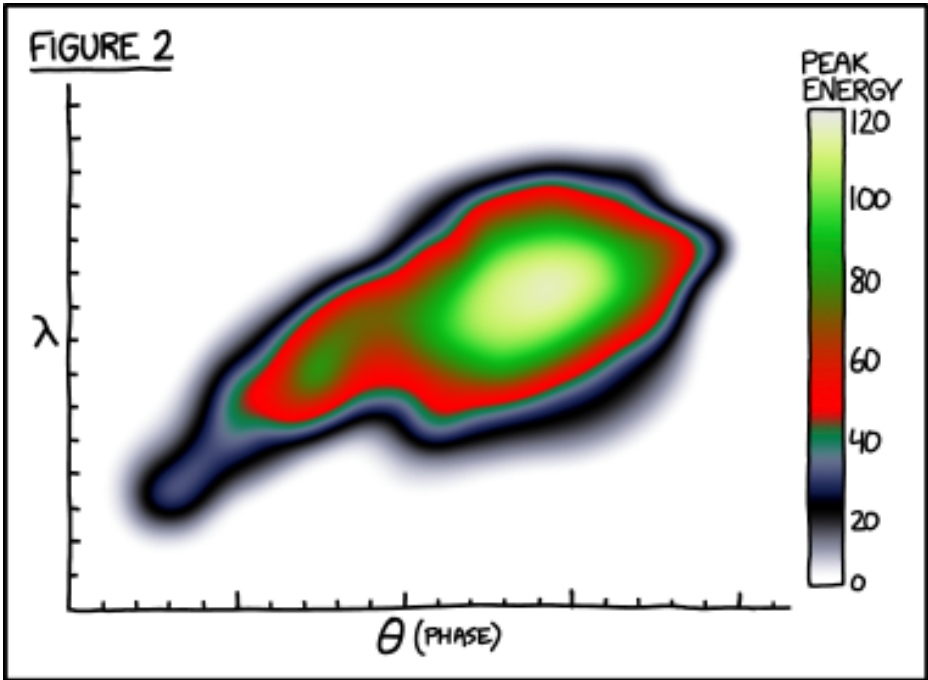
A post "reviewing" religions is sure to stir up controversy, as many religious followers are passionate about their religious beliefs and believe their religion is best. Literal wars have been fought over the idea one religion could be superior to another, and it is not a wound most practitioners are willing to reopen any time soon. Moreover, religions are typically chosen for more fundamental reasons -- such as by comparing the

likelihood that each religion makes accurate claims, or the efficacy of each religion in promoting an ethical life, or the connection a practitioner feels to the religion's rituals, metaphors, and images, or by privileging a preexisting cultural or family connection to a particular tradition -- not by comparing gimmicky features or price.

The title text mentions "budget" and "upgrade" picks, which are subcategories for reviewers - cheaper options and options that are good for upgrading your current product. Neither of these categories are typical categories for religions[citation needed] and could further anger their adherents. The association of religion and money could allude to various controversial topics such as tithing, indulgences, televangelism, or Prosperity theology (yuck). Budget need not be just about money, it could also refer to the amount of time or effort involved. (e.g., how much time is spent in religious activities, needing to learn a new language, etc.) Some religious followers might be offended[citation needed] if their religion was picked (or not picked) in a "budget" category. The idea of a religion "upgrade" evokes the highly divisive concept of supersessionism among the major Abrahamic religions, which would be guaranteed to cause further outcry no matter which one of those the article would pick for the category. (Various forms of syncretism could qualify as an "upgrade," but whatever Wirecutter's intent, that is unlikely to be the first thing anyone reading such an article thinks of.)

#2537: Painbow Award

November 03, 2021



EVERY YEAR, DISGRUNTLED SCIENTISTS COMPETE FOR THE PAINBOW AWARD FOR WORST COLOR SCALE.

This year, our team took home the dark blue ribbon, better than the midnight blue we got last year but still short of the winning navy blue.

Explanation

This comic makes fun of the badly selected color scales used in the figures for scientific papers by suggesting that the scientists picking them are in competition to use the most problematic scale. The title of the comic is a portmanteau of "pain" and "rainbow" suggesting a humorous name for terrible color scales.

The color scale here showcases a collection of unintuitive and unhelpful decisions. Starting from the top, white fades down into green, which then fades into red (passing through brown in the middle instead of yellow, indicating subtractive color mixing instead of additive color mixing, for no obvious reason). The red then turns back into green as the intensity decreases further. Red and green in close proximity make the energy levels hard or impossible to distinguish for those with protanopic color vision deficiency. This confusion is repeated at lower energy levels, where blue transitions to black and then back into white via a gray with a tiny tinge of blue. The highest and lowest recorded energy levels have the same color value, which is less than ideal. That Randall is aware of color blindness and the problems this causes has been revealed in other comics like this one 1213: Combination Vision Test.

Although it's possible (for someone with full color vision) to interpret data from this graph from context clues - the white that fades to green is high-energy white, while the white that fades to blue is low-energy white -

there's no benefit to doing things this way, and a lot of downsides. Additionally, there are regions in the color scale where the color changes very rapidly, which creates the false appearance of an edge in what is likely a smooth function.

Real-world analogues to the Painbow Award include radar meteorology charts, where different types of precipitation have different color schemes that can overlap and blend in confusing transition zones. In the field of data visualization, the CIELAB color space, perceptually uniform color spaces, or even more specialized scales have been developed to replace simple algebraic interpolation of red, green, and blue values.

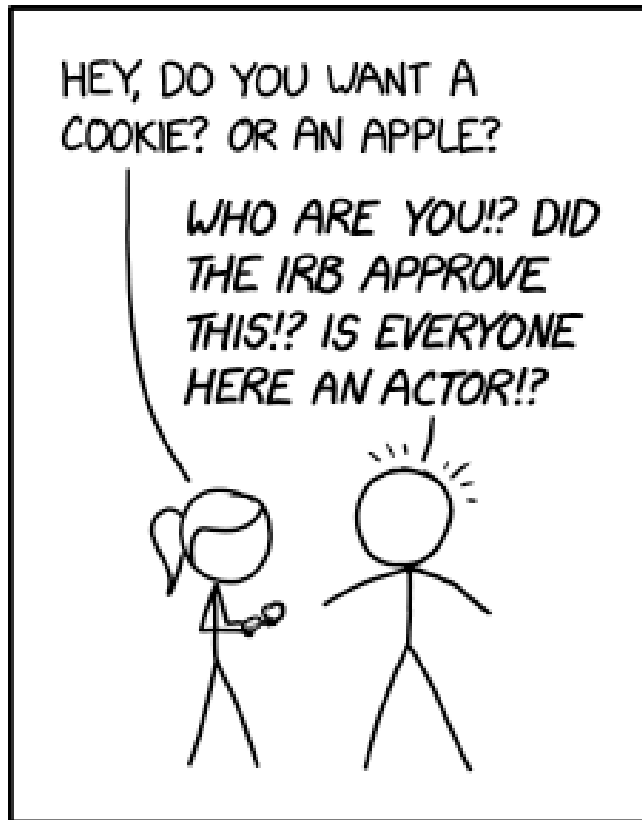
The title text takes the concept of bad color combinations further, suggesting the use of navy blue (), dark blue (), and midnight blue () for first, second, and third respectively. These are the names of three similar xkcd colors, and, as sighted readers will be able to see, there is very little difference between them.[citation needed] However, the choice of blue(s) may be a direct play upon the association of the Blue Riband (a.k.a. "Blue Ribbon") and/or Cordon Bleu (likewise, but this time direct from the French) awards, extended in common use for excellence across a much wider range of competitive fields.

For rosette-rewarded competitions (e.g. livestock parades, dog-shows, etc) the first prize ones are commonly blue (red for 2nd and either yellow or white for 3rd), though it may not be logically obvious to someone unfamiliar

with this, perhaps more used to yellow depicting the 'gold standard, first place' indicator or red as the most alerting hue in some other ranking situations. Where a depicted award schema is directly gold/silver/bronze-influenced, however, the gold and bronze 'metallic off-yellows' can sometimes be more confused with each other than with the mid-level desaturated 'silver'

#2538: Snack

November 05, 2021



THE BEST PRANK YOU CAN
PLAY ON PSYCH MAJORS IS
JUST TO OFFER THEM A SNACK.

Although grad students, suddenly reminded that food exists, tend to just grab and devour both without further discussion.

Explanation

Many psychological studies involve participants being asked to make decisions under varying conditions, to determine how those conditions influence decision making. A common example is to give subjects a choice between eating a healthy snack (such as an apple) or a tasty snack (such as a cookie), which may be used as a simple proxy for whether they're prioritizing long-term health or short-term gratification. In most cases they are not made aware of the nature of the experiment, as knowing the premise of the study is liable to influence their behavior and alter the results. Instead subjects may deliberately be given a false impression of the purpose of the study, or they may be offered a choice under conditions where they're not aware that they're part of an experiment at all.

Examples of experiments like this are the Stanford marshmallow experiment and this study.

This sort of psychological study is most commonly done by universities, which means that using university students as subjects is generally the most convenient option. This means both that psychological studies tend to be heavily skewed towards the demographics of college students, and that university students have a pretty good chance of being invited to participate in a study at some point.

The joke in this strip is based on the premise that

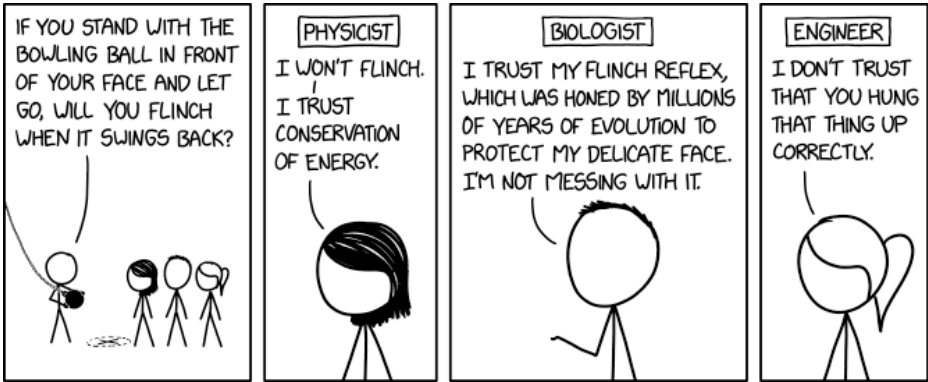
psychology majors are sufficiently aware of such studies that it would make them suspicious of any circumstances which could be part of a study. If they've studied (or even conducted) such experiments, anything that reminded them of such a study could cause them to become suspicious. In Cueball's case this is exaggerated into outright paranoia, and Ponytail is apparently playing on that to prank him, offering options that could easily be part of such an experiment just to spook him into suspicion.

Studies done on humans are subject to important ethical controls, particularly if the subjects are not fully informed of the study's purpose. "IRB" stands for Institutional Review Board, which is a committee (for example, at a university) which must approve such research to ensure that there's no significant risk of doing harm to the subjects of the study.

The title text jokes that graduate students have so much work to do that they are liable to forget to eat entirely and stereotypically too impoverished to afford adequate amounts of food; when presented with an offer of free food, they don't ponder the implications or potential ulterior motives; they just eat it quickly and get back to work.

#2539: Flinch

November 08, 2021



Premed: "Does this count for a physics credit? Can we shorten the string so I can get it done faster? And can we do one where it hits me in the face? I gotta do a thing for first aid training right after."

Explanation

Cueball is performing a common physics demonstration in which a heavy ball is hung from a rope or cable. The demonstrator, or a volunteer, pulls the ball back until it's close to their face (possibly even touching it), then releases it, allowing it to swing, and then return. Due to conservation of energy, the ball cannot return any further than its original release point, making it impossible for the person to be struck by it. Because a heavy pendulum will tend to lose little energy on each swing (relative to its overall energy), it will come back very close to its original point, so the experiment creates a conflict between the instinctive desire to escape a heavy object flying at your face, and the theoretical knowledge that it won't harm you.

Megan is a physicist, who understands the principles of the experiment and claims she won't flinch, confident that it can't harm her.

Hairy is a biologist, and implies that he has no intention of avoiding the flinch reflex, as he trusts the automatic reflexes that the human body has evolved more than he trusts the premise of the experiment. In both 755: Interdisciplinary and 1670: Laws of Physics, the same experiment is referenced. In the title text of the latter Randall makes a very similar argument as the biologist does here.

Ponytail, an engineer, replies that she doesn't trust

Cueball to have hung the pendulum correctly. Engineers are trained in science, but work with practical applications, and tend to be very aware that practice is rarely as simple as scientific theories might imply. Even if the physical laws are constant, the experiment might not go according to plan. For example, if the cable were to snap or come loose while swinging toward the subject, the ball could strike them in the body, or land on their feet. If the cable is more elastic than anticipated, it could stretch unpredictably, once again striking someone. If the anchor point is not stable, it could shift during the experiment, once again causing harm. Also if the ball is not released but pushed, or if the one releasing it leans forward after release they might get hit in the face.

The punch line basically makes the point that failure to trust the safety of an experiment doesn't necessarily imply a lack of scientific knowledge. If you lack confidence in the design of an experiment, then it's not safe to assume that the laws of physics will protect you.

The comic as a whole demonstrates that members of different disciplines have differing perspectives on the world: Physicists trust physics, biologists trust biology, and engineers do not trust engineering. This creates irony, because the reader might expect that an engineer would trust engineering, but in actuality, engineers distrust things designed by humans, since most engineers have encountered numerous examples of poor engineering design or execution.

The title text shows a pre-med student's response.

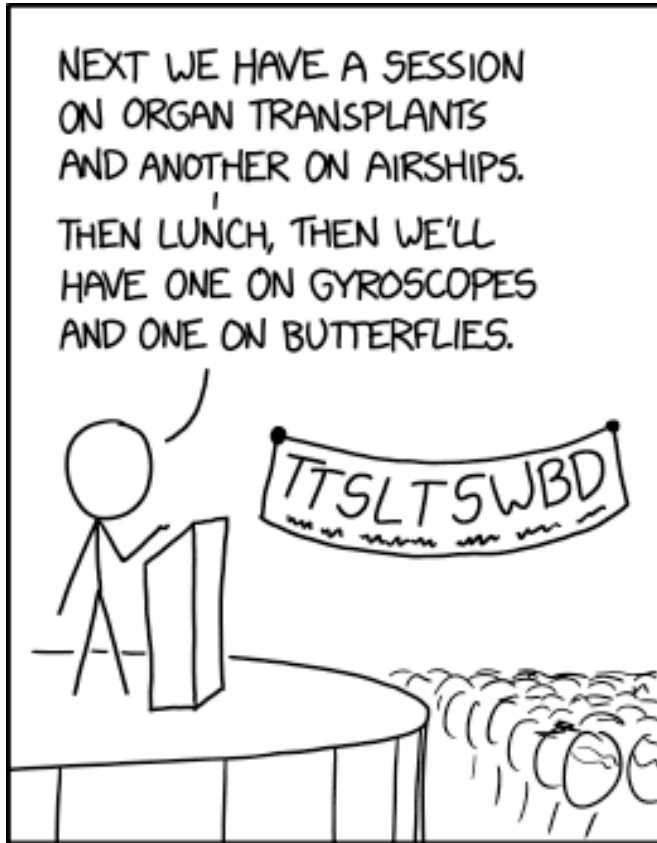
Pre-medical university courses have a reputation for being more intense and demanding than other undergraduate degrees, so the student is portrayed as being very stressed and time-conscious; showing little interest in the experiment itself, only in how it impacts their degree. In addition, medical students are commonly the subject of "interesting" medical experiments which may lead to long-term psychological and physical side-effects.

The student first asks if participating in the demonstration will count for a physics credit, implying that they're not willing to spend time on it unless it contributes to their academic requirements. They then ask if they can shorten the string to make the demonstration go faster. Shortening a pendulum does, indeed, cause it to swing faster, but the time saved would be less than the time necessary to make the modification, so the demonstration would not end sooner. Finally, they ask to do a variant where they deliberately get struck in the face, because they have a "thing for first aid training" immediately after. This would likely injure them, but the student is apparently willing to sacrifice their own safety and well-being in service to their academic career. It's not clear how this would help, although it could potentially help others learn first aid by having them practice on the new injury.

Various alternate takes on this experiment have been previously featured in 755: Interdisciplinary and 1670: Laws of Physics, but this is the first time experiment is performed in a proper manner.

#2540: TTSLTSWBD

November 10, 2021



THE FIRST ANNUAL CONFERENCE ON
THINGS THAT SEEM LIKE THEY
SHOULDN'T WORK BUT DO

Tomorrow's sessions will be entirely devoted to sewing machine rotary hooks.

Explanation

Cueball is standing at a lectern on a podium (or is it a lectern?), addressing a large crowd. He is describing the program of some event, listing the different topics that will be covered. These appear to be random, but the caption gives the punchline: it is a conference on things that seem like they shouldn't work but do.

By "things that seem like they shouldn't work", it means things that the average person would have some intuitive sense that the function of thing was impossible, and yet ample real-world experience shows that they do, and may become a routine function that people depend upon. TTSLTSWBD in the title and the banner is the abbreviation for "Things That Seem Like They Shouldn't Work, But Do".

There are two sessions in the morning (before lunch) and two in the afternoon.

Organ transplantation, where a functioning organ is cut out of one person (usually dead, though living people can donate a single kidney, cornea (if they don't mind the accompanying vision loss), lung, uterus, part of their liver (which is unique in that it will regenerate) and, depending on one's definition of 'organ', bone marrow) and put into another person where it will now operate for their benefit. Given the very complex and delicate nature of living tissue, it's rather surprising that this could work at all. In reality, it's not a simple process, and

a lot of things could go wrong, but modern medicine is advanced enough that organ transplantation is widely accepted and regularly practiced, usually functioning well enough to extend life.

Airships, or dirigibles, are huge rigid structures which are filled with bags of lighter-than-air gas, which causes the entire structure to float, and could carry both passengers and significant loads. The idea of such a huge vessel traveling, able to both move rapidly and float in place, would be hard to imagine if it didn't exist, yet zeppelins functioned and were a practical mode of transportation for a time. Unlike the other things mentioned, airships are largely obsolete (having lost favor due to safety concerns and surpassed by other technologies). Airships are a recurring theme on xkcd.

Mechanical gyroscopes are simple devices consisting of a spinning disc mounted inside three concentric gimbals as a fixture, or more often observed at work as a single spindle in a free-standing external frame that can be held or moved around by hand. The rotational inertia of the spinning disc resists change in orientation, and tends to remain in a single orientation (if free to do so) or else exert counter-intuitive forces (where directly encouraged to change its central axis). The notion that a disc can remain so steady can be counterintuitive even to those who understand the physical principles. This weirdness has been previously referenced in 332: Gyroscopes. An optical gyroscope does not mechanically resist any motion but (relying upon an effect originally exploited in a failed attempt to disprove Special Relativity) ultimately

provides similar feedback about the rotation of the unit into which it is mounted.

Butterflies fly with an unusual fluttering pattern, which works in part due to the notoriously complex principles of fluid dynamics that may look like uncontrolled fluttering but yet somehow allows the creature to land directly on specific flowerheads to feed. This is not as intuitively understandable as the flight of larger creatures such as birds.

The title text refers to rotary hooks on sewing machines, which are a complicated (and complicated looking) mechanism whose purpose is to feed one thread in a loop around a whole spool of another thread, and are apparently counterintuitive enough that the conference feels they need a whole day to cover them.

This concept is referenced in 2115: Plutonium.

The conference that the comic pictures is another example of a thing that seems like it shouldn't work but does. At first glance, Cueball seems to be listing a random, disconnected list of topics that will be covered, which runs counter to the format of most conferences. It initially seems inconceivable that enough people would be interested in all of those separate topics for the conference to make a profit (from attendance fees). However, the audience is packed, demonstrating that this is not the case. This may be because many people enjoy the mind-expanding feeling of having their intuitions shattered.

#2541: Occam

November 12, 2021



Oh no, Murphy just picked up the razor.

Explanation

This comic invokes three philosophical topics: Occam's Razor, the Barber Paradox, and Murphy's Law.

Occam's Razor is the principle that explanations should not postulate more entities than necessary. It is often phrased as "the simplest explanation is best". The word 'razor' is intended to evoke the image of shaving off superfluous elements.

The Barber Paradox postulates a town barber who shaves all those, and those only, in the town who don't shave themselves, and asks whether the barber shaves himself. The paradox is that if he does, then he shouldn't, and if he doesn't, then he should. It is an attempt at a concrete, real-world analog of Russell's Paradox in set theory.

Megan tries to invoke Occam's Razor to create a simpler solution to the paradox. Occam's Razor is named in honor of philosopher William of Ockham (Ockham being a town in England) and she declares that William shaves the barber. Her proposal is humorous and does not of course resolve the paradox, as the barber is still not shaving himself (so he should shave himself, so he shouldn't shave himself...)

The title text invokes Murphy's Law: the expectation that "anything that can go wrong will go wrong." When you shave with a cut-throat razor, there are multiple things that could go wrong, many of which would cause

harm to the person being shaved. Alternatively, invoking Murphy's law makes the principle of Occam's Razor itself or its use in the comic, "go wrong", possibly rendering the solution invalid.

#2542: Daylight Calendar

November 15, 2021



IN OUR NEW CALENDAR SYSTEM,
THE DATE CHANGES AFTER EVERY
12 HOURS OF DAYLIGHT, REGARDLESS
OF HOW LONG THAT TAKES.

Could be worse. In some towns north of here, it's already December, and the 21st will last for nearly a week.

Explanation

At the time of this posting, the United States had ended Daylight Saving Time (DST) recently, on November 7, and returned to standard time. Daylight saving time is a practice of setting clocks ahead by 1 hour during warmer months to effectively 'borrow' some of the typically unused early morning light and pass it down to the late evening where more people can make use of it. In the United States, daylight saving time starts on the second Sunday in March and ends on the first Sunday in November.

A result of ending of daylight saving time is the sun setting earlier than people are used to, as people have become acclimatized to the shifted clocks — though it does mean an 'extra' hour of light has returned to the seasonally redarkening mornings. The start of the comic may be the start of a typical comment about how the sun seems to set earlier than usual in November; which it does anyway (north of the equator) but the clock-shift makes it even more obvious.

In this comic, however, Randall turns the normal talk about DST on its head by devising a calendar system where the dates "change" based on 12 hours of daylight. This causes shorter "days" in the summer months, which may get more than 12 hours of daylight in a "solar day" and longer "days" in the winter months which would have fewer hours of daylight in a "solar day". As mentioned in the title text, this change would be very

pronounced near the poles, which may only get a few hours of daylight per 24 hours in the winter, but conversely may get 20 or more hours of daylight per 24 hours in the summer. Cueball says that he likes the new calendar system, as it gives him more "time" in the winter to complete work - if Cueball is given "3 days" to complete a task, each of those days could be longer than a typical 24 hours. However, this would be reversed in the summer, as each day would be shorter. Also, if this calendar system was in place, his boss could resolve this problem by just giving him 72 hours to complete his task instead of "3 days".

At temperate latitudes and above, as the calendar goes towards winter (for your hemisphere) the length of daylight per daily cycle shortens. Instead of having "long summer days" (i.e. periods of daylight) and shorter ones in the winter, but still the artificial pressures of a regulated 24-hour cycle to adhere to, the proposal seems to be that the date gets incremented whenever (and only when) twelve hours of daylight have passed.

In the summer, a day-count starting at sunrise could require a late-afternoon switch to 'tomorrow', which would in turn be switched earlier still the next day as it was already partly used up, with possibly two date-changes per astronomical day (early morning and mid-evening, for example). As winter draws on, not enough daylight will pass to guarantee a date-change in any single period. On the day of this comic's release - November 15, 2021 - Massachusetts, where Randall lives, gets ten hours and forty five minutes between civil

twilights. It is possible that the last day-mark was late during the previous daylight cycle and the next one won't be until early in the following one.

Exactly how the time is marked is not fully explained. Starting each day-period at 00:00 would be easiest, but could be a psychological step too far. One possibility is to set a nominal 00:00 six hours before a day-change, in line with an 'idealized' twelve-hours-of-daylight day, but disregard hours 'belonging' to a prior daylight period. Then keep the clock running (throughout any intervening nights and into the next daylight as necessary) until the date clicks over and realigns as necessary. Clock times would not reach 23:59 for most of the summer, and could far exceed that in the winter. Megan's clock has reached 26:15, by this sunset, and may well be due to be far into the 30-hours range before more daylight and the moving on to the new date and reset time, if not beyond.

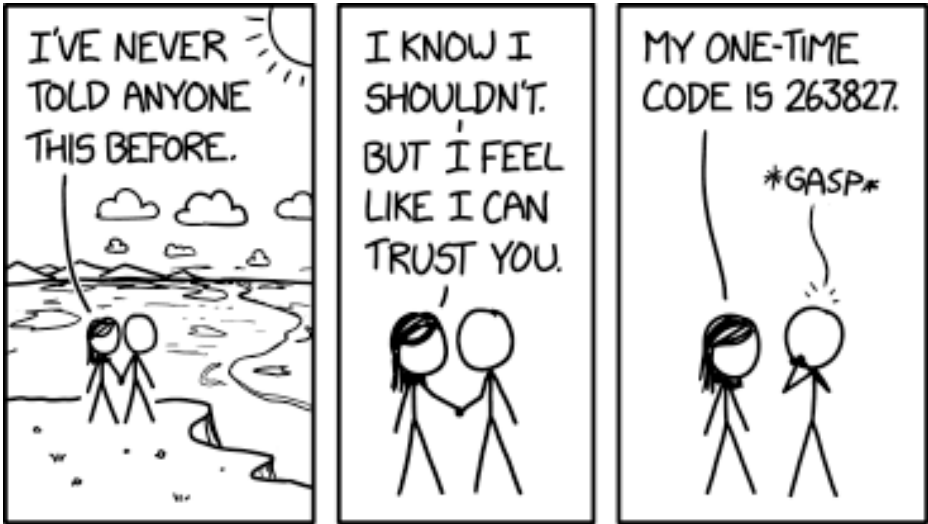
The title text relates to how days pass with respect to latitude. Depending on how exactly daylight is measured, we may have more "days" in a year than the usual 365, since refraction of light near the horizon means that the sun is visible slightly more than 50% of the year on average. This effect is strongest near the poles, since the sun spends more time near the horizon. In addition, due the Earth's elliptical orbit, more northerly parts of the Earth receive more sunlight than southerly parts. Combined, these effects mean that a year at the north pole is 381 "days", compared to 369 at the Equator.

This increase in the number of 'days' with latitude creates a situation where more northerly latitudes pass through the 'months' faster than lower latitudes, as beyond the Arctic circle, twelve hours of daylight would be accumulated upto twice per traditional day during the summer, while being effectively on hold for much of the other six months. This effect would be less pronounced outside the Arctic Circle but still create an acceleration in the passage of dates.

This creates the situation described in the title text, where towns north of Cueball's current location had increased daylight during the summer and hence accelerated through the calendar, and are currently in the '21st of December' at their latitude during winter, when periods of darkness are much longer, causing the time needed to change the date take nearly a week. This implies that they receive about 2 hours of sunlight every day in order to gain the required amount of sunlight in the timeframe given.

#2543: Never Told Anyone

November 17, 2021



Even if you said you were an employee of the website, if you asked for my password, I'd tell you.

Explanation

This comic combines stereotypes about two secrets that one would normally be reluctant to share: dark, personal secrets, and passwords. In the comic, Megan appears to be about to tell Cueball a secret of the former variety, but twists it by instead revealing a one-time code (presumably for the use of two-factor authentication for an online account). This is poking fun at the serious-looking warnings that typically accompany the generation of one-time codes. For example: "DO NOT share this code with anyone. We will NEVER call you to ask for it." While this is still something Megan should normally be reluctant to share, it has much less value to Cueball than a personal secret[citation needed] unless his intent was to steal Megan's account - and even then it's probably useless, as these codes become invalid after they're used (hence the term "one-time") or a few minutes after generation. Cueball compounds the humor by reacting with a shocked gasp, as one would be more expected to react to a dark secret.

Users are generally warned never to tell their password to anyone, not even a support representative of the site; real technical support reps shouldn't ever need your password, and anyone with a true configured-in authority should never even find it necessary to know/use it. However, one tactic that crackers use to break into accounts is to claim to be calling from the site and say that they need your password to fix some vague and/or mythical problem with the account.

Intentionally or unintentionally, Randall has chosen as the fictional one time code the last six digits of the garbage compactor number from Star Wars: A New Hope (garbage compactor 3 263827), only omitting the first digit, presumably because most one time pass codes are four to six digits long.

The title text says that Megan trusts Cueball so much that, despite knowing this, she would divulge her password to him even if he tried this approach on her. There is a further irony here, as Megan is focusing on the exception to the rule ("Don't even tell an employee" implies "You shouldn't tell anyone") as if it was the most important factor.

#2544: Heart-Stopping Texts

November 19, 2021



Was this your car? [looping 'image loading' animation]

Explanation

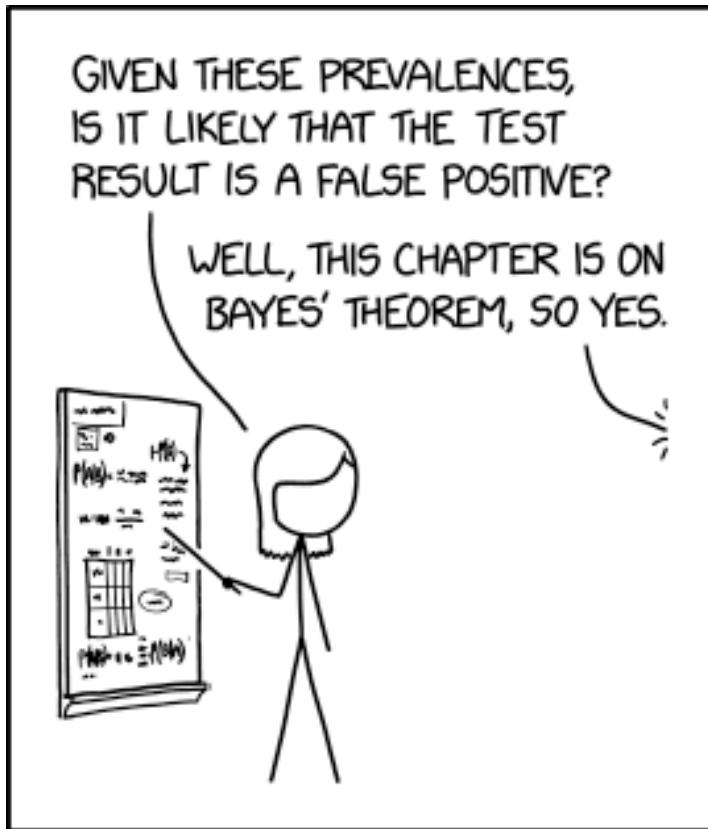
Text messages have become a ubiquitous form of communication in most countries, and have become a basic part of many people's everyday lives. Conversations over text frequently jump straight to the purpose of the communication, without salutation or prelude. Some texts, particularly when delivered without context, can carry implications that cause immediate anxiety.

"Out of the blue" is an English expression meaning "to appear in a sudden and unexpected fashion". It's a shortened version of "sudden as a bolt out of the Blue", referring to a bolt of lightning out of the clear, blue sky. The implication is that something dramatic (and possibly dangerous) has occurred without any warning signs, under circumstances where it wouldn't normally be expected.

This comic lists texts that would be worrying to receive with no context, for a variety of reasons. It seems to suggest that sending these is a good way to prank someone; particularly the title text, where deliberately sending an animated loading icon seems like it couldn't be intended for any other purpose. The different messages are explained below.

#2545: Bayes' Theorem

November 22, 2021



SOMETIMES, IF YOU UNDERSTAND
BAYES' THEOREM WELL ENOUGH,
YOU DON'T NEED IT.

$P((B|A)|(A|B))$ represents the probability that you'll mix up the order of the terms when using Bayesian notation.

Explanation

Bayes' theorem describes the probability of an event, given knowledge of conditions related to the event. It is typically used to update the probability that a starting condition occurred, given an outcome. This can reveal unintuitive results when the probability involved is very small. For example, when testing a large number of people for a rare disease, even a fairly accurate test will produce more false positives than the number of people actually afflicted with the disease, and hence a positive result is more likely to be false than true.

For example, if a test has a 100% sensitivity (first line, all those affected receive a positive result) and a 99% specificity (second line, 1% of the unaffected also receive a positive result), the interpretation of a positive test depends on the prevalence of the disease in the population. In the example case, the prevalence is 0.1% (third column), so that when the test result is positive (1% of the tests, left column) the subject is actually unaffected nine times out of ten. Although this would be a very performant test, given the relative prevalences involved it will produce overwhelmingly false positives among all positive results. (But, in this example, all those told they are not in danger — almost a hundred times more individuals than test positive — are correctly notified.)

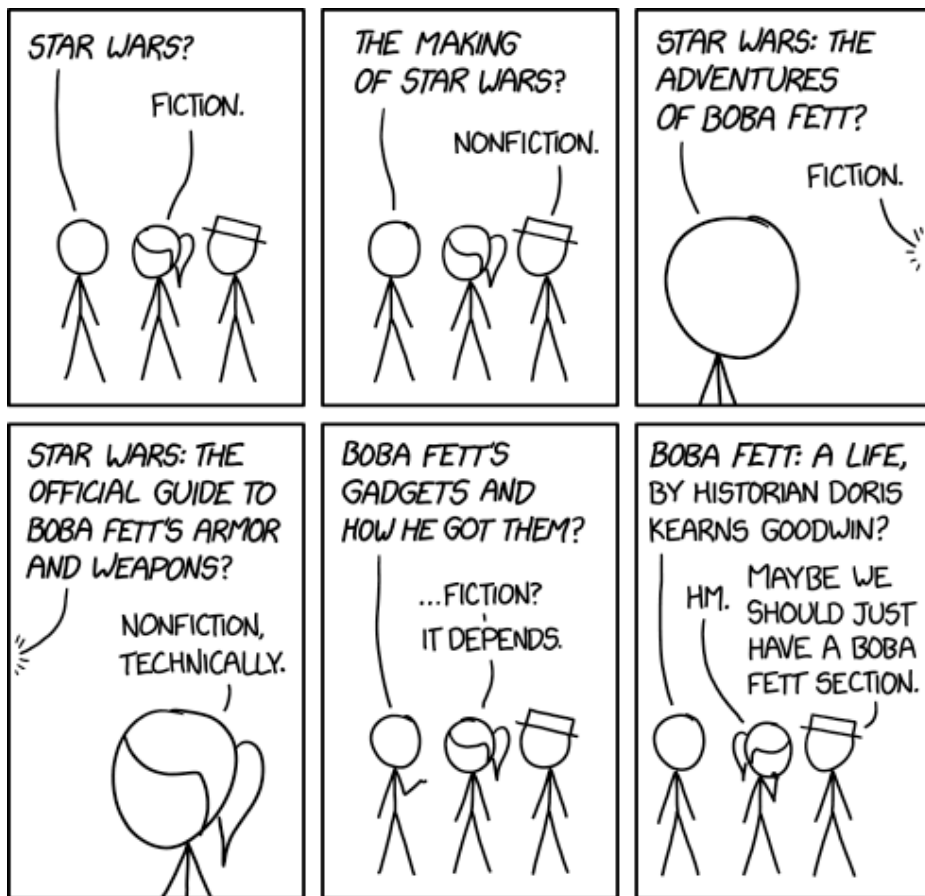
For this same example, the Bayesian formula gives :

In this comic, a teacher is presenting a problem which the students are supposed to use Bayes' theorem to solve. However, the off-panel student knows that they are studying Bayes' theorem, so they use that prior knowledge to guess the usual answer to such problems. The punch line is the caption - 'The student doesn't need to do the calculation because they're familiar with questions involving Bayes' theorem and how they often present the counterintuitive result to illustrate the importance of prevalence to the calculation.

The title text refers to the mathematical definition of Bayes' theorem: $P(A | B) = P(B|A) * P(A) / P(B)$. Here, $P(A|B)$ represents the probability of some event A occurring, given that B has occurred. This is often referred to as "the probability of A given B". It can be hard to remember if $P(A|B)$ means probability of A given B, or if it's B given A, especially when talking about the probability of an earlier cause given a later effect. Randall's joke is based on this difficulty. Here $P((B|A)|(A|B))$ is meant to be read as the probability that you write $(B|A)$ given that the correct expression is $(A|B)$, which makes it the probability that you got the order of the notation mixed up.

#2546: Fiction vs Nonfiction

November 24, 2021



The real challenge is how to file Boba Fett's biography of Doris Kearns Goodwin.

Explanation

Cueball is asking Ponytail and White Hat to classify different Star Wars books and movies as fiction or nonfiction. (Perhaps he is working at a library or bookstore, or sorting a personal collection.) Star Wars as a whole is a multimedia franchise, which includes films, TV series, novels, etc, but often singularly refers to the original 1977 film later more lengthily titled Star Wars: Episode IV – A New Hope (or, given the fact that the rest of the titles are books, one of several novelizations based on the script). The classifications get more complicated to determine as the conversation progresses while revealing a quite specific obsession with the character of Boba Fett. The complexity may even end up converting lumpers into splitters, a philosophical distinction that another recent comic touched upon.

Nonfiction (also spelled non-fiction) is any document or media content that intends, in good faith, to present only truth and accuracy regarding information, events, or people. In contrast, fiction offers information, events, or characters expected to be partly or largely imaginary, or else leaves open if and how the work refers to reality.

In the end, White Hat suggests that, since Cueball has so many works featuring Boba Fett, it would be more useful to group them together in a new category rather than sorting them into the fiction and nonfiction sections.

Table[edit]

#2547: Siren

November 26, 2021



CIRCE WAS ACTUALLY JUST TELLING
ODYSSEUS TO IGNORE HIS GPS.

Directions from CITY OF TROY to ITHACA / Total time: 10y
54d 14h 25m / Warning: Route crosses an international
border / route includes capture by the goddess Calypso /
route includes a ferry

Explanation

Odysseus is the hero of the Greek epic *Odyssey* by Homer. This is a poem that relates the journey of Odysseus back home to his homeland from the newly defeated Troy, and how he inadvertently angered Poseidon thus causing the journey to take 10 years.

In the story, now widely translated and adapted for modern audiences, Circe warns Odysseus of the Sirens, who sing beautiful songs that lure sailors towards their shores, just to doom the boats to sink upon the jagged rocks surrounding their islands. In Odysseus's own case, the Sirens even claim to be able to "tell you everything that is going to happen over the whole world"; at this point, Odysseus has been away from home for many years and has no idea if his wife and son remember him, so the temptation to stay and listen (and thus find out if he will be able to return alive) is especially powerful.

This comic reframes the advice as if Odysseus was being told to ignore the incorrect instructions of a GPS-linked routefinder, rather than the Sirens. Errors, omissions or out-of-date information in the databases used by such devices famously have sent drivers down roads they might never have even tried to use (guided by printed maps, road-signs or even past experience) without the alluring voice of the 'infallible' dashboard device leading them through too-narrow lanes, into rivers or even hundreds of miles completely out of their way - perhaps to a destination similarly-named to their intended one.

GPSs did not exist during the time the poem was written,[citation needed] so this could not be the case here.

A navigation system giving wrong directions can happen, for example, due to outdated or incomplete map data. Sometimes users can file an error report with the provider of the navigation system and hope that they fix the problem in a software update. This is what Circe already did multiple times. However, the error was not fixed, so she has to resort to telling Odysseus to ignore the route.

The title text shows what the route description could have looked like, had Odysseus indeed used a modern navigation system. It includes the start and destination of the route, the estimated duration and warnings about special circumstances of the journey.

Normally, the sea voyage from the City of Troy to Ithaca should take much less than ten years. For Odysseus it took so long because of the many obstacles he had to face, so the navigation system would have some sort of clairvoyance function built in.

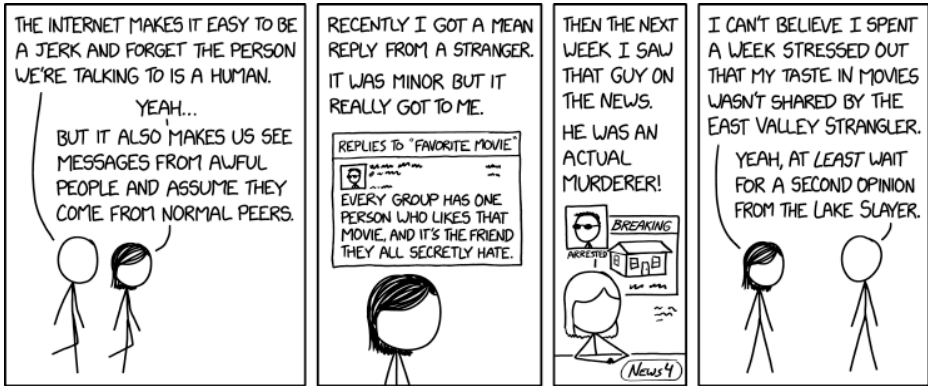
"Route crosses an international border" and "Route includes a ferry" are standard warnings included in a route description. The former alludes to the facts that Odysseus's voyage took him to many lands and kingdoms while the latter may allude to the fact that in Book XI of the *Odyssey*, Odysseus visits Hades, which is traditionally reached by a ferry across the river Styx, piloted by

Charon the ferryman. "Route includes capture by the goddess Calypso" is not normally something that a navigation system would warn about or could know about,[citation needed] but this indeed happened to Odysseus in Homer's tale; he was kept on her island Ogygia for seven years.

The weird directions in the title text may be a reference to 461: Google Maps.

#2548: Awful People

November 29, 2021



Hm, this burger place has a couple of good reviews, but LakeSlayer7 says he got food poisoning there and everyone should try this other place down by the lake instead.

Explanation

Megan and Cueball are having a conversation about social media. Cueball mentions that when responding to textual comments on a screen, it can be easy to forget these comments are made by thinking, feeling humans (a sentiment expressed before on XKCD). Megan agrees, but also relates a negative comment she got from a stranger about her taste in movies. The twist is that it turns out the person criticizing her was a murderer, "the East Valley Strangler". Although this does not inherently negate his taste in movies, it does free Megan from the burden of weighing his opinions equally to her own.

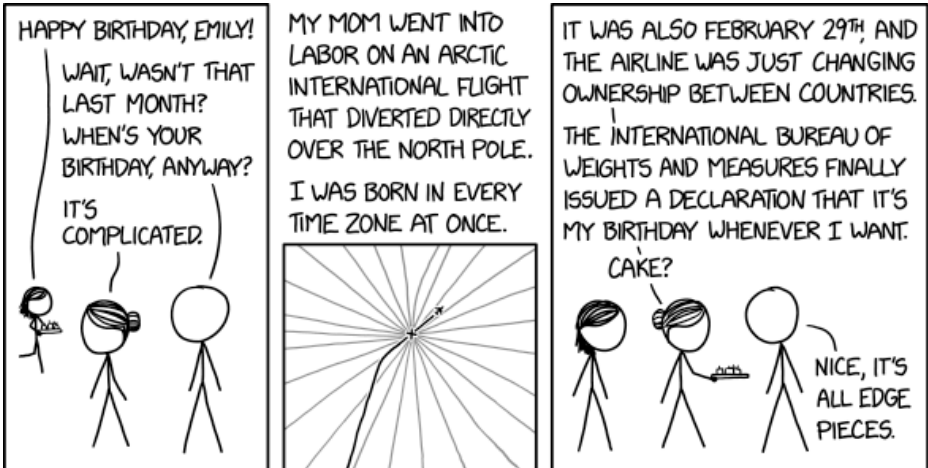
The title-text mentions the "LakeSlayer7" which is clearly a reference to the "Lake Slayer" in the comic. They mention, contrary to several other reviewers, that a burger joint in town is unsatisfactory, and that the reader should come to a place "by the lake" instead, which probably is a plot to lure people to the lake and to be slain.[citation needed]

In many social and news sites there is a tendency to surface negative content. This can be editorial intent, naive algorithms, or both, attempting to induce rage to drive engagement. Review sites can exhibit a bias in either direction, with minutiae burying valid feedback.

The East Valley Strangler's involvement with the incident at East Valley Nuclear Plant is currently unconfirmed.

#2549: Edge Cake

December 01, 2021



Every time IERS adds or removes a leap second, they send me a birthday cake out of superstition.

Explanation

Megan—possibly an IERS (International Earth Rotation and Reference Systems) agent—wishes Emily, represented as Hairbun, Happy Birthday. This prompts a confused Cueball to ask if her birthday was sometime last month. Emily explains that she was born over the North Pole in a plane, meaning that she was born in every timezone at once. Technically though this is false, as there are some timezones (such as UTC+5:45) that are not represented at the north pole. Except for the one hour before it's midnight at the International Date Line, the date in eastern time zones is one day ahead of western time zones, so Emily would have been born on two days at once.

She also says that it was February 29th (presumably it was also February 28 or March 1 in some time zones). February 29th only happens at most once every four years in the Gregorian calendar, adding to the confusion - people born on February 29th often celebrate their non-leap-year birthdays on arbitrary days (or not at all). Normally one could simply use the time zone of the city the airplane took off from, but the airline company was changing ownership from one country to another at the time, so this option has apparently been ruled out. This is not terribly logical, however, since contracts transferring ownership usually specify an exact time (commonly one minute before or after midnight in a specific time zone to avoid confusion on which day midnight is in) to come into effect. Regardless of which time zone(s) she was in

when she was born this is an absolute time and if she was born before it she would have been born in an aircraft of the first country and if after it in an aircraft of the second country. Alternately, the time zone of the city the aircraft took off from doesn't change even if the nationality of the plane changes in midair, so that should have still been an option.

The punchline is that rather than try to identify the correct birthday for Emily, the BIPM has decided to let her have birthdays whenever she wants. This doesn't make much sense, however. As noted above even if she was born in every time zone at once it could only have been on one of two days (February 29th, plus either February 28th or March 1st). Since it is common for people born on February 29th to celebrate on February 28th in non-leap years, it would have been trivial to pick the non-leap day present in some of the time zones (either February 28th or March 1st) and declare it Emily's birthday. It's possible that Emily was told "You can choose when you want your birthday to be", and Emily decided to exploit the lack of specificity to the degree presented in the comic.

In real life researchers in the Arctic at or near the North Pole use Coordinated Universal Time as the local time standard by convention, to avoid this exact problem. Thus it could have been said that Emily was born on the date that it was at that time in UTC. Furthermore, it is extremely unlikely that she would have been born at the exact instant the plane was over the north pole, indeed, it is unlikely that the plane even traveled over the exact

pole, as opposed to a few miles or even feet to either side of it. With modern positioning equipment such as GPS, it should have been possible to determine which time zone the plane was in when she was born. Even in the impossibly unlikely event that she was directly above the pole at the instant of her birth, at jetliner speeds the plane was traveling about ten miles per minute, so a reasonable delay of even seconds in declaring "time of birth" would have placed the plane and her clearly in one time zone.

Both the comic title and Cueball's final line are puns on "edge case", an engineering term referring to situations or conditions that are unusual in a way likely to cause problems unless specifically accounted for. Edge pieces are generally only important with sheet goods (brownies, sheet cakes, etc), which are typically cut into pieces creating a difference between pieces originating on the edge and pieces originating from the center. Since the top and sides of a cake are often frosted, an edge piece has two faces covered in frosting and a corner piece has three, while a center piece only has one. Depending upon your relative preferences between the surface (often icing over marzipan) and core body of the cake (which can be fruitcake, or some variety of spongecake, etc, but not actually obvious which until the cake is cut), it being an edge-faced slice can be considered a bonus. Cueball certainly seems to appreciate this.

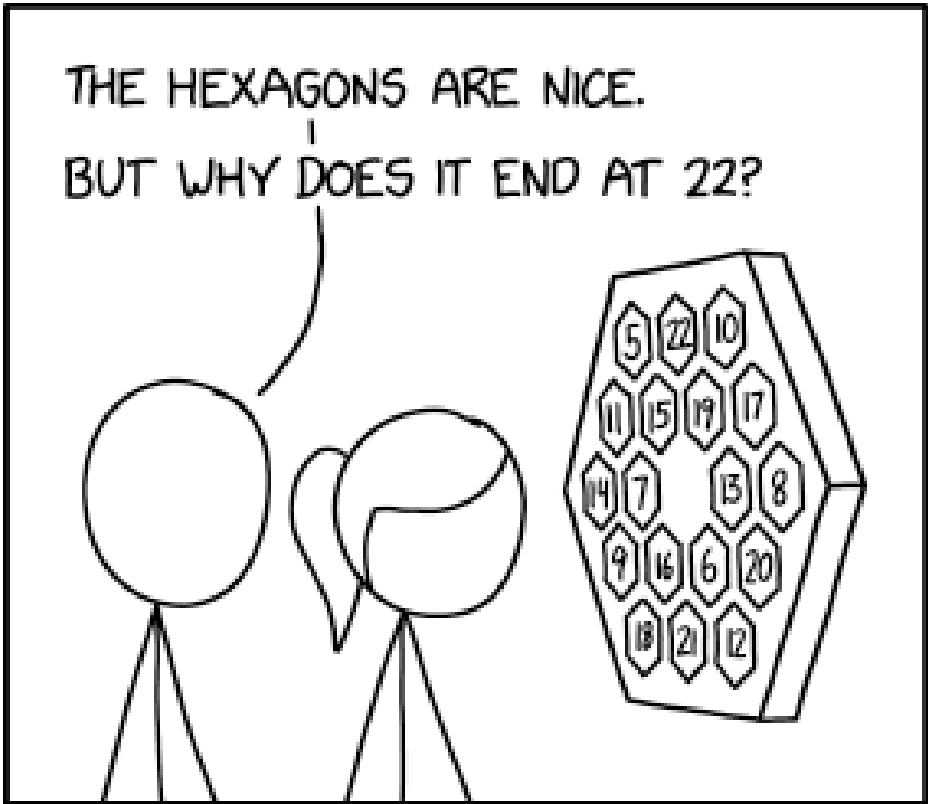
The title text states that the IERS sends Emily a cake every time they add or remove a leap second, out of superstition (perhaps Megan is delivering that cake). The International Earth Rotation and Reference Systems

Service is in charge of global time standards. It occasionally adds one leap-second to Coordinated Universal Time to adjust for changes in the rotation speed of the Earth.

The comic might also be a modern version of the SS Warrimoo, a passenger liner that reportedly crossed the international date line at the equator on midnight Dec. 31, 1899. This would have placed her bow in the Southern Hemisphere on 1 January 1900, her stern in the Northern Hemisphere on 31 December 1899. She would therefore have been simultaneously in two different hemispheres, on two different days, in two different months, in two different years, in two different decades, and according to some definitions in two different seasons (northern winter and southern summer) and possibly in two different centuries.

#2550: Webb

December 03, 2021



ASTRONOMER ADVENT CALENDAR

Each one contains a chocolate shaped like a famous spacecraft and, for the later numbers, a pamphlet on managing anxiety.

Explanation

This comic depicts a special advent calendar: instead of celebrating the Christian Advent by counting down to December 25th, it instead celebrates the launch of the James Webb Space Telescope by counting down to December 22nd.

At the time this comic was published, the James Webb Space Telescope (JWST) was scheduled to be launched on the 22nd of December, 2021 (after many prior delays). Christmas would indeed have come early for astronomers if the launch had been successful and on time. By December 14, the launch date had been pushed back again to "no earlier than December 24", as NASA was working on resolving a communications issue between the observatory and its launch vehicle system. This was followed by another delay announced on December 21, when the launch date was pushed back to December 25, due to weather concerns. It was successfully launched from Kourou in French Guiana on December 25 at 09:20 FGT (12:20 UTC, 07:20 EST), as hoped for in this comic: 2559: December 25th Launch.

A normal advent calendar marks the days until Christmas by allowing miniature doors to be opened, or other means of revealing some treat/picture. This is often from the 1st of the month until the 'big reveal' on the 24th or 25th, though other schemes may exist in other cultures. This particular calendar features 18 hexagonal features, intended to be sequentially accessed over several

days, in the same layout as the 18 gold-beryllium mirror segments designed to fold out to form the JWST's primary mirror. The first door is on the 5th, two days after this comic's publication date, making the last on the 22nd, the 'Big Day'.

Cueball's question could be interpreted two ways: Cueball doesn't know about JWST, so he is asking why this advent calendar ends before Christmas (and possibly fearing this calendar is similar to the one in 1245: 10-Day Forecast); or Cueball does know about JWST and its history of delays, so he is asking why the calendar ends on 22 when there is no certainty in that launch date (and also implying that he expects it to be delayed). [Note: two weeks after the comic was posted, the JWST was again delayed, this time to no earlier than Christmas Eve (and later finally to Christmas Day itself), making the expectation accurate. This would also make a traditional advent calendar serve equally well, were it not for the hexagon design.]

The title text references the fact that chocolates in advent calendars are often molded into different shapes, and the fact that the later numbers have a "pamphlet on managing anxiety" is probably supposed to quell the impending fear that the launch could be delayed further or go wrong. The telescope's launch was initially planned for 2007, but due to various redesigns, financial issues, accidents, flaws, and the COVID-19 pandemic, the launch date was pushed back to 2011, then 2013, 2018, 2020, May 2021, October 2021, and finally to the current launch date in December 2021. It may also allude

to post-launch concerns; even if the launch goes well, there will still be nervousness about the complex 160-day process in which the JWST reaches its intended observation point 930,000 miles from Earth, many subsystems are unfolded/deployed, and the instrument passes its final calibrations. There is effectively no way to rescue/repair this expensive piece of equipment should anything be amiss, unlike the Hubble Space Telescope, which was visited five times by Space Shuttles to remedy and enhance various features. (There exist issues with even Hubble that cannot currently be considered repairable without the Shuttles or any proven replacement, and the JWST will be located far beyond Hubble's operational orbit in a place much more difficult to get to.)

The JWST has been referenced previously in 1730: Starshade, 2014: JWST Delays and 2447: Hammer Incident, mentioned in 1461: Payloads as well as indirectly in 975: Occulting Telescope. After this comic it was referenced in 2559: December 25th Launch and 2564: Sunshield.

#2551: Debunking

December 06, 2021

AP PHOTOS SHOW DR. FAUCI'S
OFFICE CONTAINS A NORMAL
NUMBER OF MICROWAVES

AP PHOTOS SHOW DR. FAUCI'S
OFFICE CONTAINS A NORMAL
NUMBER OF MICROWAVES

FACT CHECK: SINGER
BILLIE EILISH WAS BORN
YEARS AFTER THE TWA
FLIGHT 800 EXPLOSION

VACCINATED PEOPLE CAN REMOVE
THEIR HATS WITHOUT TROUBLE BY
TUGGING UPWARD, SAY DOCTORS

VACCINATED PEOPLE CAN REMOVE
THEIR HATS WITHOUT TROUBLE BY
TUGGING UPWARD, SAY DOCTORS

PHYSICISTS SAY
DORITO POWDER
IS AFFECTED
BY GRAVITY

STEERING WHEELS WILL
WORK NORMALLY ON
DEC 12TH; MAKE LEFT AND
RIGHT TURNS AS USUAL

STEERING WHEELS WILL
WORK NORMALLY ON
DEC 12TH; MAKE LEFT AND
RIGHT TURNS AS USUAL

CNN INVESTIGATION: SANTA'S
SKIN IS DRY AND HEALTHY
THIS YEAR, WITH THE SAME
AMOUNT OF OIL AS BEFORE

CNN INVESTIGATION: SANTA'S
SKIN IS DRY AND HEALTHY
THIS YEAR, WITH THE SAME
AMOUNT OF OIL AS BEFORE

I DON'T KNOW WHETHER THE "DON'T REPEAT THE CLAIM
IN THE HEADLINE DEBUNKING IT" THING WORKS OR NOT,
BUT IT DEFINITELY MAKES READING THE NEWS WEIRD.

Mark Zuckerberg has only neutral feelings toward Peppa Pig, who he understands is a fictional character, and he blames the coronavirus pandemic on other factors.

Explanation

When writing a news article that "debunks" a claim (shows why it is false), writing its headline in the form "X is false" is discouraged. The reason is that just repeatedly seeing "X", even if negated or followed by "is false", can make readers subconsciously believe it.

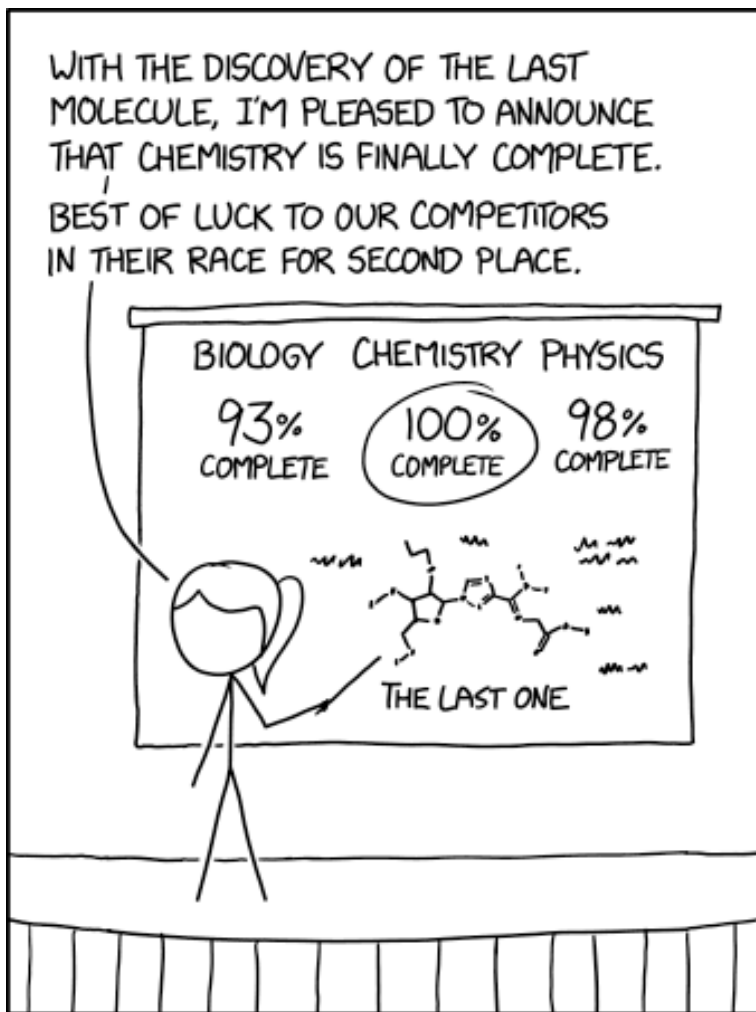
To avoid this, Randall as a journalist has worded his debunking articles in a positive sense. This makes for a confusing read if the reader has not heard of the original claim. The "original claims" allegedly being debunked here don't actually appear to have been made anywhere, and can only be inferred from the debunking.

Much of the debunking relies on setting simple facts straight, making for bizarrely banal headlines.

Table[edit]

#2552: The Last Molecule

December 08, 2021



Biology is really struggling; they're barely at 93% and they keep finding more ants.

Explanation

This comic jokingly proposes a situation in which chemists have discovered and cataloged every single possible molecule. Thus they declare they have "completed chemistry." Both parts of this are humorously incorrect.

In real life the number of ways to arrange atoms into molecules grows combinatorically with the number of atoms in a molecule. Since molecules can be extremely large (up until the point where gravity takes over and initiates nuclear fusion), the number of possible combinations is much much larger than the number of particles in the observable universe, making the full cataloging of all molecules impossible. Thus, a "final molecule" cannot be reached.

Even if it were possible to catalog every molecule, though, chemistry would not be completed. This is because chemistry is not simply about cataloging molecules: rather, it's the study of how molecules, and atoms, interact with themselves and each other. The goal of any science is not to "complete" a field, but to understand it better and better.

Adding to the humor is the very high percentages, and the precision, given to the other fields shown in the comic. Putting Biology at 93% and Physics at 98% is patently absurd. As mentioned in the title text, we can't even give a definitive answer to deceptively simple

questions like "How many kinds of ant are there?"

If biology were simply a matter of cataloguing species, we are currently at around 10-20%. Even this estimate is hard to nail down, partly because species are being constantly created and recategorized. Even if it were possible to know exactly what animals were alive on Earth at any one moment, and which could interbreed, there would still be no agreement on the number of species they constituted. And even if were possible to catalog every species, biology would still be faced with fundamental and important problems such as what genes promote which traits, the nature of cognition, and the mechanism behind several diseases.

As for physics, the 2012 detection of the Higgs Boson did complete the experimental detection of all the elementary particles of the Standard Model of particle physics. However, questions such as "what is dark matter?", "how do we unify the four fundamental forces?", "how do we make nuclear fusion possible on earth?", and "how many dimensions does the universe have?" make it clear that the field still has a long way to go.

The title text makes fun of Biology lagging behind due to finding more ants. There are very many species of ants and other insects: when J.B.S Haldane, founder of the field of population genetics, was asked what he learned about God from studying creation, he reportedly said "God is incredibly fond of beetles".

#2553: Incident Report

December 10, 2021

FACILITY	DATE	REPORT ID
EAST VALLEY NUCLEAR PLANT	12/10/2021	9603120071
EVENT DESCRIPTION		
<p>ROUGHLY 18 HOURS PRIOR TO THE INCIDENT, AN AMAZON PACKAGE CONTAINING FIREWORKS WAS MISTAKENLY DELIVERED TO THE REACTOR CONTROL ROOM AND LEFT UNDER THE CONSOLE.</p> <p>THE NEXT DAY, AT APPROXIMATELY 14:00, TECHNICIAN A ARRIVED AT THE FACILITY WITH A BAG CONTAINING FOUR JUGGLING PINS. AT 14:20, TECHNICIAN A ENTERED THE CONTROL ROOM AND JOINED TECHNICIAN B AT THE CONSOLE.</p> <p>AT 14:28, TECHNICIAN C EXITED THE ELEVATOR AND APPROACHED THE CONTROL ROOM HOLDING A BIRTHDAY CAKE INTENDED FOR TECHNICIAN B.</p> <p>AT 14:29:22, TECHNICIAN A SAID "HEY [TECHNICIAN B], CHECK OUT THIS COOL TRICK I LEARNED" WHILE TAKING OUT THE JUGGLING PINS. TECHNICIAN B TURNED TO LOOK JUST AS, AT 14:29:26, TECHNICIAN C ENTERED HOLDING THE CAKE.</p>		

YOU KNOW THINGS ARE ABOUT TO GET BAD WHEN THE INCIDENT REPORT STARTS INCLUDING SECONDS IN THE TIMESTAMPS.

Increasing-precision timestamps are the Jaws theme of incident reports.

Explanation

An incident report describes the sequence of events when something goes wrong, including the lead-up as well as the aftermath. This usually involves describing at what time related events happen. In this comic, a report at a nuclear power plant on the day of the comic's publishing starts with particularly vague timestamps (that a package of fireworks arrived "roughly 18 hours prior" to it), then uses approximate minute-level precision ("14:00" and "14:20", which could reasonably be five minutes off in either direction), then minute-level precision ("14:28"), then second-level precision ("14:29:22" and "14:29:26").

This suggests that the clock time is really a proxy for the amount of time before one specific moment where everything falls apart, and when seconds start appearing, it implies that the recollection is within a few minutes of the disaster. Normally the increased level of precision reflects close monitoring capabilities of the affected systems, reviewing monitoring equipment, such as surveillance camera and microphone recordings, and/or detailed analysis by incident investigators. It may have been sufficient for the resulting inquiry to merely note the prior arrival of the original package, and possibly then read off (whatever remains of) the signing-in logs for the approximate times each member of staff arrives on the scene. At some point, though, the investigation will refer to fully timestamped security recordings, perhaps even eventually frame-by-frame with particular

interest in exactly which things touched exactly what other things, in sequence, in order to hopefully learn all the necessary lessons about the incident.

Synchronization of events is important in incident investigations, so often systems are required to take input from common, relatively precise time references, such as GPS, WWV broadcast, or cellular telephone systems. For example, an aircraft crash needs radar positioning data synced with voice communications and flight recorder data. Lack of correlation between these is a potential source of conspiracy theories, for example one of the hijacked planes on 9/11 crashed into Pennsylvania either at 10:03 or 10:06 depending on two different information sources.

In many situations, incident reports are anonymized as shown to protect the identities of those people involved in the incidents. This is often done to prevent unnecessary blaming of certain individuals, particularly when it hasn't yet been determined whether the incident was negligence or just an accident.

Examples of real-life incident reports with second-level precision timestamps showing the increasing precision around critical moments include:

- Explosion of the Space Shuttle Challenger
- Chernobyl explosion
- Three Mile Island Accident
- 2021 United States Capitol attack

The report shown cuts off before reaching the actual incident, leaving it to the reader to imagine what happened next. If the birthday cake has lit candles, one possible sequence of events is that a dropped or badly thrown juggling pin could have hit one of them and then rolled over to the fireworks package, thus igniting the package. This would have caused the fireworks to go off underneath the reactor control's console.

Although the comic refers to juggling "pins", jugglers commonly call those props "clubs." It is possible Randall is confusing the similarly shaped objects in 10-pin bowling to juggling clubs. "Pins" are another name for a component of Uranium Carbide type nuclear fuel rods, which are involved in the safe control of the nuclear reaction within a nuclear power plant. No sane reactor staff would juggle these complex, heavy and expensive pieces of equipment.[citation needed]

The title text refers to the theme music from the 1975 film Jaws, which has come to represent impending danger. Movies use music to create the correct emotional tone; suspenseful music indicates that something bad is about to happen. The Jaws theme is an iconic example, famously used to create a sense of foreboding, then uses increasingly rapid tempo to build a sense of imminent danger, culminating in a dramatic moment of disaster (a shark attack, in the film). As with the increasing tempo of this theme, the increasing precision with which events are recorded in an incident report build the increasing sense that something terrible is imminent.

9603120071 is an actual accession number for an incident at San Onofre Nuclear Generating Station in 1996. Four slightly contaminated stray kittens were found, cleaned, and adopted. No clock times were mentioned in the report.

Real-world nuclear power stations have strictly regulated control rooms which would prevent the simultaneous presence of fireworks, juggling and birthday celebrations. There is no East Valley nuclear power plant (just the East Valley Strangler), but there are two reactor units at the nuclear power plant in Beaver Valley, Pennsylvania.

#2554: Gift Exchange

December 13, 2021



THE PERFECT GIFT FOR
A POLITICAL SCIENTIST

In addition to having all their budgets in a spreadsheet with consistent formatting, they just love expressing preferences on a well-calibrated numerical scale.

Explanation

In December, white elephant gift exchange parties are popular, in which party-goers bring and exchange presents, via a variety of procedures which often involve individuals taking turns to pick a present. Usually they can either pick a wrapped present and open it, or take a present that someone else has opened already.

Many political scientists think that creating a fair gift exchange is a really tricky problem, since it involves different valuation of various goods (one person might like socks while another person would not), a possible incentive to misrepresent how much you value things ("You're going to have to offer me a LOT to give up these socks, because I really like them"), arbitrary order effects (who goes first matters), and more. These problems have a lot of political analogues in the political science topics of social choice theory and mechanism design, and many political scientists dedicate years of their life to figuring out the best solutions. Therefore, a political scientist would enjoy the challenge of creating a fair gift exchange; it is the best gift that Ponytail could have given them.

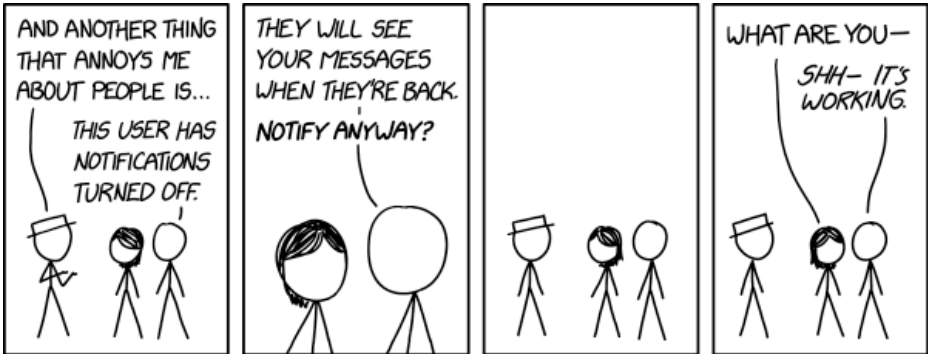
The scenario Ponytail presents is formally known as a fair item allocation problem, for which there are various approaches to how to define fair, and various proposed allocation algorithms, some of which are computationally intractable even for small numbers of participants.

The fact that the family loves surveys implies that a favourite method of political scientists, surveying the electorate, would be greatly appreciated. The "It's okay if it's complicated" line is funny because many of the theoretically best solutions a political scientist might come up with would be very complicated – far more so than the typical person would want to think about.

In the title text, having well-formatted budgets makes a scientist's job much easier since it is better for data manipulation. In the same way, expressing preferences on a well-calibrated numerical scale makes data manipulation simple and straightforward. Therefore, Ponytail's scenario is an excellent gift for the political scientist. It also extends the humorous scenario of the nerdy family who enjoy filling in complex surveys – the same family would be likely to enjoy a well-formatted budget spreadsheet.

#2555: Notifications

December 15, 2021



It's 10:34 PM for this user. They really need to get going, they have a thing early tomorrow. Are you sure you want to notify?

Explanation

Many devices will notify the user when something of possible interest occurs (e.g., a new phone call is received, a load of laundry is done). Some, such as the instant messaging software Slack, allows you to turn notifications off while you're offline or away (or just don't want to be disturbed). Such a function would be desirable in real life, as illustrated here. The sender can sometimes override this and notify the user anyway.

White Hat is telling Cueball and Megan about "another thing that annoys [him] about people," which means that either the strip begins after he has already vented a long series of gripes, or he is prone to spontaneously airing one of his many grievances non sequitur. (Both of those traits could be something that annoys Cueball about people.) Cueball responds by "turning off his notifications" from White Hat. White Hat immediately falls silent, sparing Megan and Cueball from further boring "conversation". Maybe Cueball has picked up the "Commented" trick, White Hat is thrown off by the unusual statement, or it could be that he just naively takes Cueball at his word. Either way, now that he "knows" that he will not receive any further immediate engagement from Cueball, he thus gives up, for the time being, talking at Megan and Cueball about his annoyance(s). If he believes the premise, he might recite the rest of his conversation as soon as Cueball supposedly turns notifications back on. His behavior is reminiscent of a user who is logged into a chat server but is "away

from keyboard" and totally disengaged.

Megan starts to ask Cueball what he's doing, but Cueball shushes her to let it 'keep working' -- presumably, if Megan speaks up, she might alert White Hat that Cueball is still listening and draw him back into conversation.

In the title text, this is taken even further by combining this with a standard real-life reason (or excuse) to leave a social situation: that the person has to leave because it is getting late. It is often used when someone really has a thing early the next day and wants to get home early to get enough sleep to be prepared for the "thing", but the vagueness of the thing suggests that they just want to get out of uncomfortable company or situations.

The specific time, 10:34 pm, informs the messenger (who could be anywhere) of the user's time zone, and tells the one that wishes to notify that it is past the normal bedtime in the user's time zone. And this is why the program would normally ask if they still really wish to notify them, since they would risk waking the recipient up. This could cause annoyance if the message is not urgent and important. In this case, however, it is clear he is awake and wants to leave the social situation, supposedly because of a thing he has the next day. In this situation, it is funny because apparently it's Cueball talking about himself in the third person to another person who knows they are in the same time zone, and unless all of the characters are out really late it's unlikely that it's actually that late at night in "Cueball's time zone"

at the moment.

An alternate explanation is that the comic highlights how strange it is that the "This user has notifications off, Notify anyway?" pop-up can sometimes leave one paralyzed with indecision, despite the fact that it does literally nothing to stop you from sending the text as normal. If it pops up when you send a text, now you have to decide whether your text is important enough to notify the person you have texted, even though they have notifications off. It's the same situation as if you're told that your boss is doing something important. You could be paralyzed, trying to figure out whether "the machine ran out of batteries" is more important than whatever generic "important thing" the other person is doing. Plus, now you have to factor in things like whether your interruption will cause more harm than help, how long it'll take, etc.

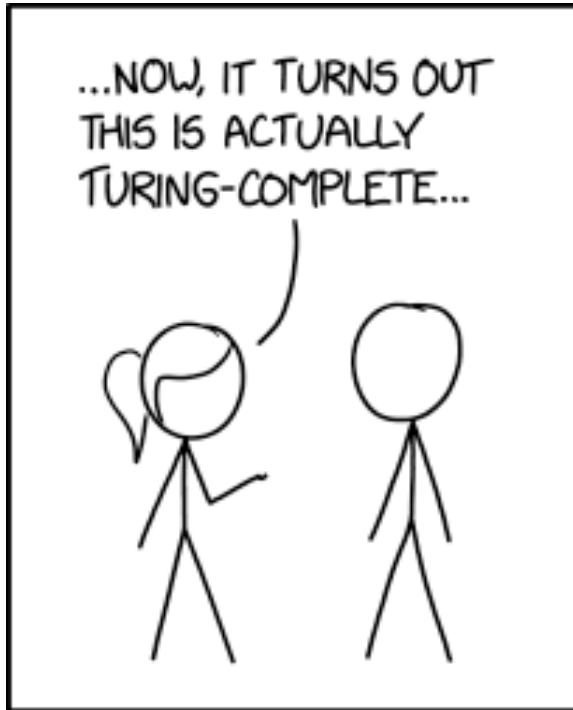
If Cueball just "Blocked" notifications from white hat, White Hat would simply be annoyed and just keep talking (because blocking implies that you just don't want to talk anymore.) However, by giving White Hat the option to "Notify anyway", Cueball paralyzes White Hat with indecision, as shown by him not doing anything for multiple panels.

This is ironic, as when users are given the option to "Notify anyway", it basically renders the action of turning off notifications useless because anyone can bypass the system. However, it still works to stop most message notifications, because no one wants to bypass

the filter and risk annoying the person who turned off notifications. This may be why Cueball shushes Megan to let it 'keep working'; If Megan speaks up, White Hat might realize that Cueball's 'filter' does literally nothing to stop his messages, and White Hat would resume his rant.

#2556: Turing Complete

December 17, 2021



THIS PHRASE EITHER MEANS
SOMEONE SPENT SIX MONTHS
GETTING A DISHWASHER TO
PLAY MARIO OR YOU'RE UNDER
ATTACK BY A NATION-STATE.

Thanks to the `ForcedEntry` exploit, your company's entire tech stack can now be hosted out of a PDF you texted to someone.

Explanation

A Turing machine is a theoretical computer that has an infinite tape of symbols. It can read and change the symbols on the tape as it moves up and down this tape according to a set of instructions (program).

This very simple machine can be shown to do every computational task that what we think of as a "computer" can do, given the right program and enough time. Something that is Turing complete is able to act as a Turing machine, though generally physical examples are limited to having a finite tape,[citation needed] and this means it is also able to do basically every computational task.

Many pieces of hardware and software are supposed to be Turing complete (even Excel, as previously pointed out in 2453: Excel Lambda). Some other things turn out to be Turing complete, even if they weren't designed for it (for instance, the tabletop game Magic: The Gathering or, at least within xkcd meta-reality, rocks in a desert). Whatever Ponytail has been referring to is not shown, but it seems to be an anecdote about how something seemingly too simple and/or specialized to exhibit such a computational equivalence has been discovered to actually be that capable. Ponytail may refer to the recent articles about the background of the NSO zero click exploit for iPhones, e.g. this.

Mario is the lead character in a long running series of

video games including Donkey Kong, Super Mario Bros and Mario Kart. Running video games, such as Doom, is one common way of demonstrating the ability to run arbitrary programs on devices that were not intended as general purpose computers. With complex processors being installed in more and more devices, it's plausible that someone could get a dishwasher to play Mario.

However, another reason to make a device run arbitrary code is to breach security. If the owner of a system assumes that it can only do one specific thing, like operate a dishwasher, they may not take precautions against hacking. But if the system is actually Turing-complete, a hacker could potentially make it do something else, like become part of a botnet. Therefore, "this is actually Turing-complete" could be the prelude to a complicated hacking attempt. Sophisticated hacking attacks are often the work of hackers that have the support of a government, or nation-state.

The ForcedEntry exploit is a way that was developed to allow PDF files to force malware onto various devices. PDF files are normally used to present documents. The exploit uses a PDF's ability to do logic operations on pixels to implement a simple virtual CPU within one of the PDF renderer's decompression functions. Constructing a CPU in this way is similar to how a hardware CPU is made of individual logic gates. ForcedEntry was publicized a few days before this comic came out.

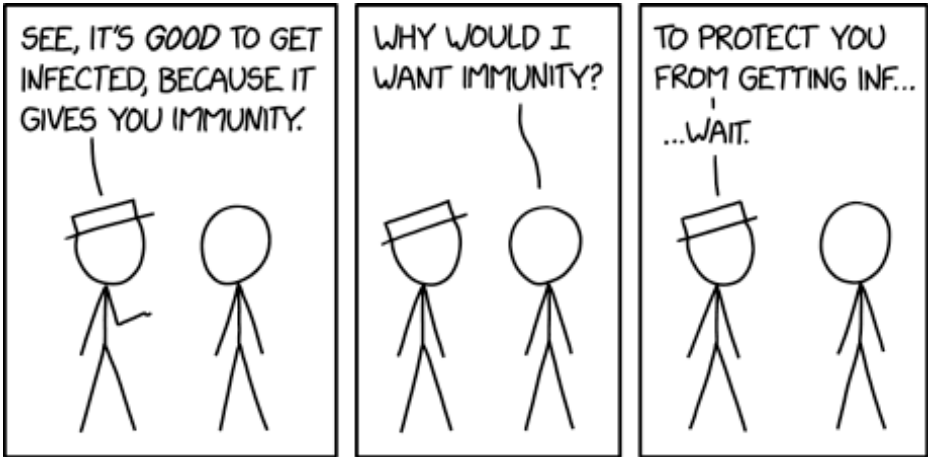
In the title-text it is suggested that this mechanism can be

used for what might be more legal and practical purposes, although this might be up to some interpretation depending upon who has the right (and permission) to do what.

A tech stack is one shorthand way of describing the way an integrated grouping of communicating software packages provides everything from the deepest data handling (even as low-level as an operating system itself) to the user interface. All of these will normally be on a computer (or possibly many of them, whether locally or distributed worldwide) and if a sufficiently functional surrogate system is capable of emulating this (computing what the original computer(s) would do) then it can be considered to effectively be the same stack of technology and duplicate or replace the originals.

#2557: Immunity

December 20, 2021



This plan may sound appealing to people who know a little about the immune system, but the drawbacks are clear to people who know a lot about the immune system and also to people who don't know anything about it.

Explanation

This comic is, although not specifically referenced, another entry in a series of comics related to the COVID-19 pandemic.

A common issue posited by people opposed to vaccination, especially during the COVID-19 pandemic, is that there are other ways to become immune to diseases caused by viruses or bacteria — most notably, contracting the disease "naturally".

Cueball, by way of questioning, points out to White Hat that this makes no sense. Contracting the natural disease is the thing people are trying to prevent. Diseases are bad.[citation needed]

Although there are plenty of instances where someone has already recovered, and therefore is in possession of natural immunity, it would be better to have that immunity without getting sick at all. Especially with a disease like COVID that can cause permanent damage to the lungs, brain, and other organs even to those who eventually clear the virus, and catalyses its effects with the immune system in a novel and dangerous manner. Additionally, COVID can be contracted multiple times. Vaccination provides similar immunity without the dangerous effects of infection. While explaining that getting infected is the best way to avoid getting infected, White Hat thus realizes the circular logic that may be attributed to anti-vaxxers (2806: Anti-Vaxxers), and thus

stops mid sentence.

The title text elaborates on this by pointing out that people with no understanding of the immune system will understand that contracting a disease to avoid contracting a disease is a bad idea, and that people with a strong understanding of the immune system will understand the specific ways it can fail (and that vaccines are generally considered to provide a greater benefit for less risk). It is thus only people with a limited understanding of the immune system, who know that infection can provide immunity but haven't thought out the disadvantages of catching the disease, who would make a claim such as White Hat does.

The comic does not specifically reference vaccines and anti-vaxxers. It could also be about people who refuse to wear masks and social distance during the pandemic, who do not understand how much they are putting other people at risk. White Hat may even be fumbling an explanation of his previous 2515: Vaccine Research into why vaccines are good.

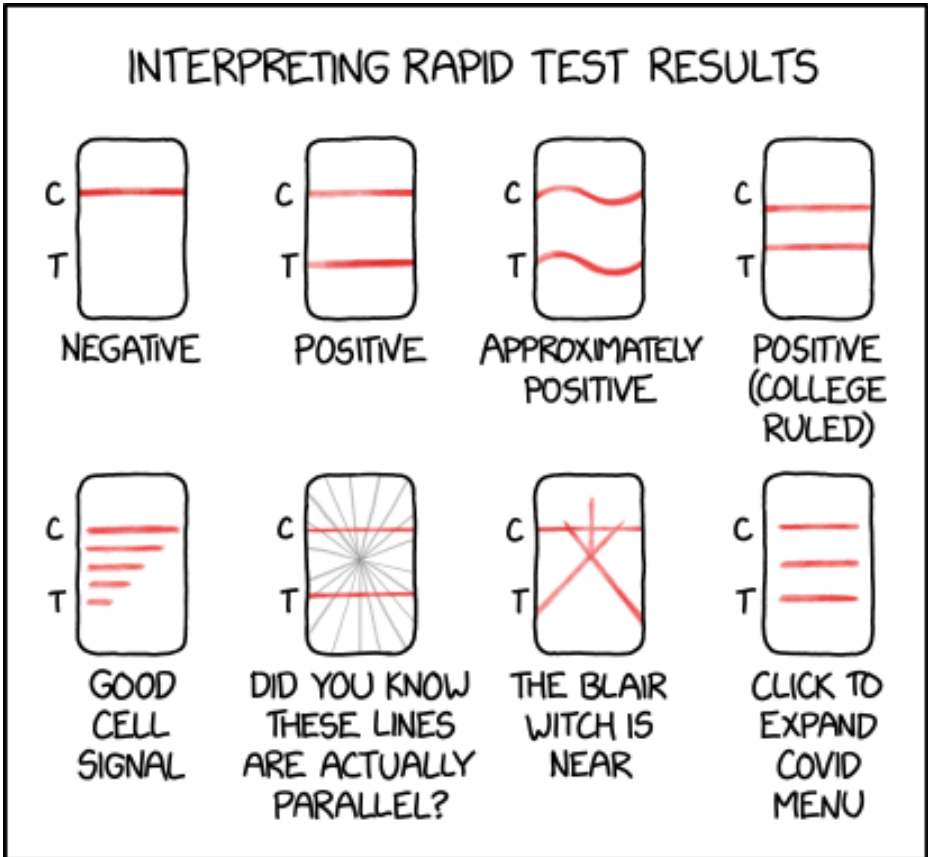
Older folks may be familiar with the "infection gives you immunity" trope due to their experience with so-called "childhood diseases". Before there were vaccines for e.g. measles, mumps, and chickenpox, it was seen as preferable for young children to contract these diseases, because the risk of serious illness is greater for those who get "first infections" later in life. Children run a comparatively smaller risk of serious illness in return for (usually) life-long immunity. Note that this only ever

made sense for children whose immune system is still flexible enough to adapt, and not for 30 something fitness bros. Furthermore, the trope has outlived its context. Small as the risk to children of serious illness from measles, mumps, and chickenpox might be, vaccines all but eliminate the risk of contracting serious symptoms at all, so many say there is no sensible reason to subject oneself to infection.

The trope, moreover, is misapplied to COVID-19, because, on present evidence, immunity from infection is short-lived (which, at least at the time of this comic, was exacerbated by the fact that variants with sufficiently different spike proteins to at least partially evade natural immunity (such as beta, delta, and omicron) were arising at a rate of multiple per year), so there is no benefit to be gained by running the risk of winding up in the hospital - or the morgue. The better comparison is to influenza, which people get vaccinated against every year. Instead of childhood diseases, think of diseases that had a high probability of serious illness at any age, such as poliomyelitis and smallpox, for which few accepted the "infection gives you immunity" trope (even though, for those diseases, infection typically yielded life-long immunity), and there was far less resistance to effective vaccines once these became available.

#2558: Rapid Test Results

December 22, 2021



A solid red area with two white lines means that you have been infected with the anti-coronavirus, **COVID+19**, which will cure anyone you have close contact with.

Explanation

This comic is another in a series of comics related to the COVID-19 pandemic.

This comic is a joke about COVID-19 rapid lateral flow test results. These devices are used in many countries for individuals to test their own nasal and oropharynx fluid for evidence of COVID-19 virus to detect asymptomatic infection. These tests have two indicator strips - a test line for covid-19 and a control line to check the device is working correctly. Where a control line is not present, the test should be ignored and repeated. Until comparatively recently pregnancy was the occasion most familiar for requiring this form of test.

The first 2 answers are the standard indicators for a negative and positive result, but Randall takes this to absurdity, see below in the table.

The title text interprets the hyphen in "Covid-19" as a negative sign to make a mathematical joke. Here Randall postulates a counterpart virus to Covid-19, resulting in a test with inverted colors, which he names Covid+19. When combined this anti-coronavirus exactly matches the original one and results in zero Covid, curing those who had previously been infected.

This was the last comic before this year's Christmas comic. It was about Covid-19 testing. The last comic before the 2020 Christmas comic, 2402: Into My Veins,

was about the Covid-19 vaccine.

Table of results[\[edit\]](#)

#2559: December 25th Launch

December 24, 2021



Update: Santa has been destroyed by the range safety officer.

Explanation

This comic was the Christmas comic of 2021.

The James Webb Space Telescope (JWST) is a space telescope jointly developed by NASA, the European Space Agency, and the Canadian Space Agency. It has suffered many, many delays over its development period (as previously referenced in 2014: JWST Delays), but it finally launched on Christmas day, December 25, 2021.

In this comic, the James Webb Space Telescope is finally ready to take off. However, an unfortunate circumstance occurs: Santa Claus himself, presumably on his way to or from delivering presents to children, crosses into the path of the launch rocket. The joke is the implication that, right on the brink of success, this extraordinarily unlucky incident will either destroy the telescope, harm Santa, or cause yet another delay, much to Cueball's horror.

Real launch aborts have occurred with fewer than 2 seconds left in the countdown, causing delays of over a month.

According to the title text, the range safety officer has made the decision to shoot down Santa Claus's sleigh, in order to clear the sky above, protecting the launch window. This seems to demonstrate that they are determined not to let anything delay the launch any further (or that given a choice between destroying the telescope or destroying Santa, the range safety officer

chooses the latter). "Range Safety Officer" is the job title of a person in charge of the safety of a launch. Range safety officer and other similar range officers are the subject of 2876: Range Safety. That was the first comic after New Years day in 2024, so seems like Randall contemplated rocket launches around the Holidays... Also earlier in the Christmas comic of 2023 he also killed Santa using Hydrothermal Vents. Before this he has only killed Santa back in 2008 in the 2008 Christmas Special.

Airspace is normally closed to air traffic to avoid collisions between aircraft and rocket launches. While Santa might not know about such restrictions, he already knows about this particular launch because thousands of astronomy geeks have asked for a new space telescope as a Christmas present in their letters to Santa, and the easiest way for Santa to deliver such a present is just keeping a safe distance from the launch pad. Moreover NORAD tracks Santa's flying around the world and would be able to give sufficient warning to both Santa and Ground Control to prevent such a close encounter of a festive kind; as well as to prevent accidental global thermonuclear war by confusing a small herd of flying reindeer with a first-strike attack by a foreign power. Finally, Santa Claus performs deliveries overnight, while the launch is scheduled for morning local time, so the timing of such a collision would not occur.

The JWST has been referenced previously in 1730: Starshade, 2014: JWST Delays, 2447: Hammer Incident and 2550: Webb, is on the list of payloads in 1461: Payloads and its planned use was indirectly referenced in

975: Occulting Telescope. Santa is known to maintain a list of humans responsible for technological incidents and to have suitable punishment for offenders. 12 days after launch it was referenced again in 2564: Sunshield.

Trivia about posting time[edit]

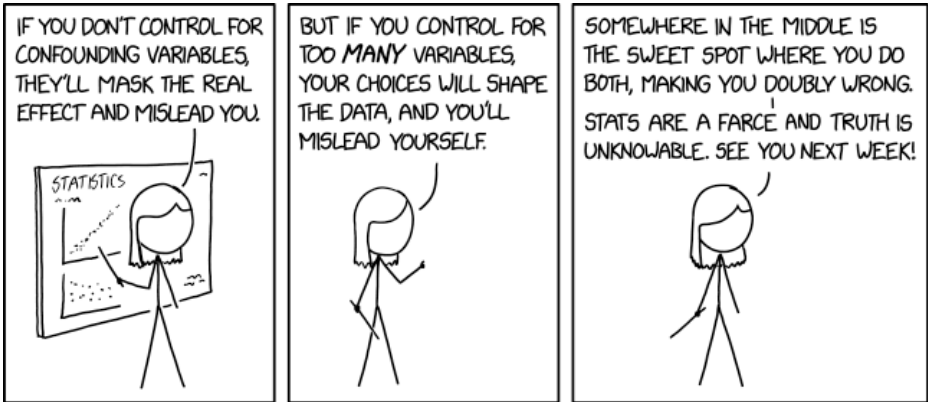
The release day of this comic was Christmas Eve the 24th of December. As can be seen from when this page was created 05:02:00, 25 December 2021 (UTC), the comic came out at least 7 hours before launch which was 12:20:00, 25 December 2021 (UTC). Since Boston (Randall's home town) is 5 hours after UTC then the comic must have released close to midnight on the 24th for Randall, and clearly before midnight for the rest of the time zones in the US.

Web comics are usually drawn some time in advance. When this comic was drawn and scheduled for publication, it is possible NASA had not yet announced that the launch of JWST was slipping from Christmas Eve to Christmas Day.

The launch was probably three days after Randall opened the last number in his Webb advent calendar. (Thus this is the second Christmas comic this year referring to the telescope).

#2560: Confounding Variables

December 27, 2021



You can find a perfect correlation if you just control for the residual.

Explanation

Miss Lenhart is teaching a course which apparently covers at least an overview of statistics.

In statistics, a confounding variable is a third variable that's related to the independent variable, and also causally related to the dependent variable. An example is that you see a correlation between sunburn rates and ice cream consumption; the confounding variable is temperature: high temperatures cause people go out in the sun and get burned more, and also eat more ice cream.

One way to control for a confounding variable by restricting your data-set to samples with the same value of the confounding variable. But if you do this too much, your choice of that "same value" can produce results that don't generalize. Common examples of this in medical testing are using subjects of the same sex or race -- the results may only be valid for that sex/race, not for all subjects.

There can also often be multiple confounding variables. It may be difficult to control for all of them without narrowing down your data-set so much that it's not useful. So you have to choose which variables to control for, and this choice biases your results.

In the final panel, Miss Lenhart suggests a sweet spot in the middle, where both confounding variables and your

control impact the end result, thus making you "doubly wrong". "Doubly wrong" result would simultaneously display wrong correlations (not enough of controlled variables) and be too narrow to be useful (too many controlled variables), thus the 'worst of both worlds'.

Finally she admits that no matter what you do the results will be misleading, so statistics are useless. This would seem to be an unexpected declaration from someone supposedly trying to actually teach statistics[citation needed], and expecting her students to continue the course. Though there is a possibility that she is not there to purely educate this subject, but is instead running a course with a different purpose and it just happens that this week concluded with this particular targeted critique.

In the title text, the residual refers to the difference between any particular data point and the graph that's supposed to describe the overall relationship. The collection of all residuals is used to determine how well the line fits the data. If you control for this by including a variable that perfectly matches the discrepancies between the predicted and actual outcomes, you would have a perfectly-fitting model: however, it is nigh impossible (especially in the social and behavioral sciences) to find a "final variable" that perfectly provides all the "missing pieces" of the prediction model.

#2561: Moonfall

December 29, 2021



Novel ideas and cool explosions are both good, but what I really want from a movie is novel ideas **ABOUT** cool explosions.

Explanation

Megan asks Cueball if he is excited for the release of the movie *Moonfall*.

Moonfall was released in February 2022, a couple of months after this comic. Its director, Roland Emmerich, is known for blowing up things in his movies (see for instance the Roland Emmerich Supercut), as well as for factual inaccuracies in his work (mainly the scientific implausibility of his many disaster movies like *Independence Day*, *The Day After Tomorrow* and *2012*).

The basic premise of *Moonfall* is that a mysterious force manages to knock the Moon out of its orbit, leaving it on a collision course with the Earth. This is scientifically preposterous (see analysis below), making it potentially 'cringe-worthy' for someone who prefers hard science fiction where things are more grounded in established scientific facts and theories. Cueball states that a story based on good science can potentially serve as a novel window into what the real world may look like someday—or, as he puts it, "expand our ideas of what's possible."

But Cueball then goes on to imply that he's still looking forward to the movie because his less critical side is still excited by things like cool spaceship noises and smashing moons into things. Sometimes you just want to get lost in mindless action, even if it's less 'mature' than a

well-thought-out meaningful plot. Megan then sums things up by playing off Cueball's wording from the previous panel, saying she's excited to "expand our ideas on how much stuff can explode at once." Given the scale of Moonfall's premise involving a potential planetary-scale collision, as well as the director's tendency to use gratuitous visual effects and explosions in his movies, it seems reasonable to conclude that the movie will likely contain quite a lot of stuff exploding at once.

In the title text Cueball continues by explaining that while novel ideas and cool explosions are good, what he really wants from a movie is novel ideas about cool explosions. So new ways to explode things, or ideas about exploding more things at once. Or both!

1536: The Martian contains a similar discussion of an (at the time) upcoming movie, in particular The Martian. In that case, however, the subject of the comic was the movie's high scientific accuracy and lack of huge explosions, rather than the other way around.

Realistic analysis of the scenario[edit]

For the Moon to fall from the sky, it would have to stop orbiting. Most forces applied to it will simply change the way in which it is orbiting, making the orbit more elliptical, larger or smaller. To stop it from orbiting entirely, a 'braking' force would need to be applied in the opposite direction of its travel, to halt it.

The Moon's mass is about 7.34767×10^{22} kg and its speed about 1.022 km/s, so the energy needed to stop it is $\frac{1}{2}mv^2$ or about 3.8364×10^{28} joules. That's about the energy of 1 trillion large

nuclear explosions, centered on the leading-most point of the Moon's surface. In theory, a precisely-oriented stellar body could strike the Moon to do this, for example, if something the mass of Ceres impacted at 16km/s. This would be dramatic. [citation needed] It would, however, be below the Moon's gravitational binding energy, which, since the Moon is densest near its center, is much greater than $3Gm^2/5r = 1.2 \times 10^{29}$ joules, so the Moon would not be immediately entirely destroyed. It is, however, about the right amount of energy to liquify the entire Moon, if it takes an average of 450kJ/kg to melt the lunar rock, then it comes out to 3.3×10^{28} J to liquify the Moon. Whatever the exact details of the impact are, it would be bad for the Moon, and it is implausible that it would result in the Moon falling into the Earth.

Less counteractive energy could make the Moon change orbit to one with a perigee below the surface of the Earth, close enough to (partially) enter the atmosphere or merely bring it down beneath the applicable Roche limit. These scenarios would be only technically less catastrophic, and whether the Moon fragments from the initially applied force, the stresses of its nearest (non-contact) distance to Earth or actually survives largely intact until there is a more direct physical interaction, the precise degree of the effect might be practically academic.

#2562: Formatting Meeting

December 31, 2021



Neither group uses iso 8601 because the big-endian enthusiasts were all at the meeting 20 years ago.

Explanation

In the United States, it's common to write dates numerically in the format month/day/year — 2/3/22 means February 3rd, 2022 (the century digits may often be omitted when it's 'obvious' that the date is in a given century range). In Europe, the usual order is day/month/year — so 2/3/22 is (the) 2nd (of) March, 2022.

"Localization" (also known as L10N) is the technique used in software to make it accept input and display output in the formats most natural to users in their locations. For example, in the United States numbers use commas "," to separate thousands and a decimal point "." to separate the decimal values, while in large areas of the EU it is the reverse. And the textual output will be translated to the local language. Naturally, this also includes displaying dates in the local format, as described above. Localization may also include the adoption of the tax law to the location, for instance when adopting tax software made for the US to the UK.

The joke in this comic is that two dates are shown, on the same display, relating to meetings regarding localization. The date of the meeting of the US team is localized in the US format while the EU team's meeting is localized in the European format, and these two dates (about a month apart) happen to be formatted the same. Cueball needs to explain that the European meeting will be a month later than the US meeting to avoid any confusion due to

the ambiguity. Which is ironic, since the aim of localization is to reduce such confusion.

A further interpretation, which extends also into the title text, is that these groups may have been supposed to meet on the same day. But even the committee that was supposed to fix these problems messed this up. Cueball may be 'explaining' the staggered approach to cover up that the two groups are already reading the date(s) for the meeting quite differently.

ISO-8601 specifies a date format of YYYY-MM-DD (e.g., 2021-12-31), which results in dates being listed in chronological order when sorted stringwise. The ISO format is called "big-endian", which refers to the fact that the most significant unit in the date (the year) comes first. The European format is instead "little-endian", as the front-end value represents the finest possible distinction the date can convey — the particular day. The American format is "middle-endian", or occasionally "mixed-endian", since the value given first is the one which is neither the one with greatest significance nor the most precise.

The joke in the title text is that it appears some people attempted to interpret the improperly formatted date as if it were expressed in the more ISO-8601 style of format of "Y/M/D". They read the date as 2002, March 22nd, so they already went to their meeting almost 20 years ago.

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